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CHARLES D. WALCOTT, DIRECTOR

IRRIGATION SYSTEMS OF TEXAS

BY

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, D. C., June 1, 1902.

SIR: I have the honor to transmit herewith a paper entitled Irrigation Systems of Texas, by Thomas U. Taylor, professor of civil engineering at the University of Texas. This paper contains the results of field work carried on by Professor Taylor through several years in connection with the measurement of the principal rivers of Texas and the investigation of the best methods of utilizing the water resources of the State. I recommend it for publication in the series of pamphlets on Water Supply and Irrigation.

A report on the same subject was prepared in 1897 by Mr. William F. Hutson, and printed as Paper No. 13 of this series. Since that time considerable development has taken place in the utilization of water in Texas, and the ground has been gone over with greater thoroughness, resulting in obtaining a larger and more complete presentation of the subject.

In the present report Professor Taylor has discussed the principal irrigation systems in general geographic order, and has given statistics as to the location, cost, and benefits of the devices for obtaining water. He has also devoted some attention to the irrigation of rice, a business in which large amounts of capital are being invested. There has been appended a brief statement of the laws governing irrigation in the State of Texas, also some of the facts obtained from the recent census investigation.

Yours, with respect,
F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

IRRIGATION SYSTEMS OF TEXAS.

By Thomas U. Taylor.

INTRODUCTION.

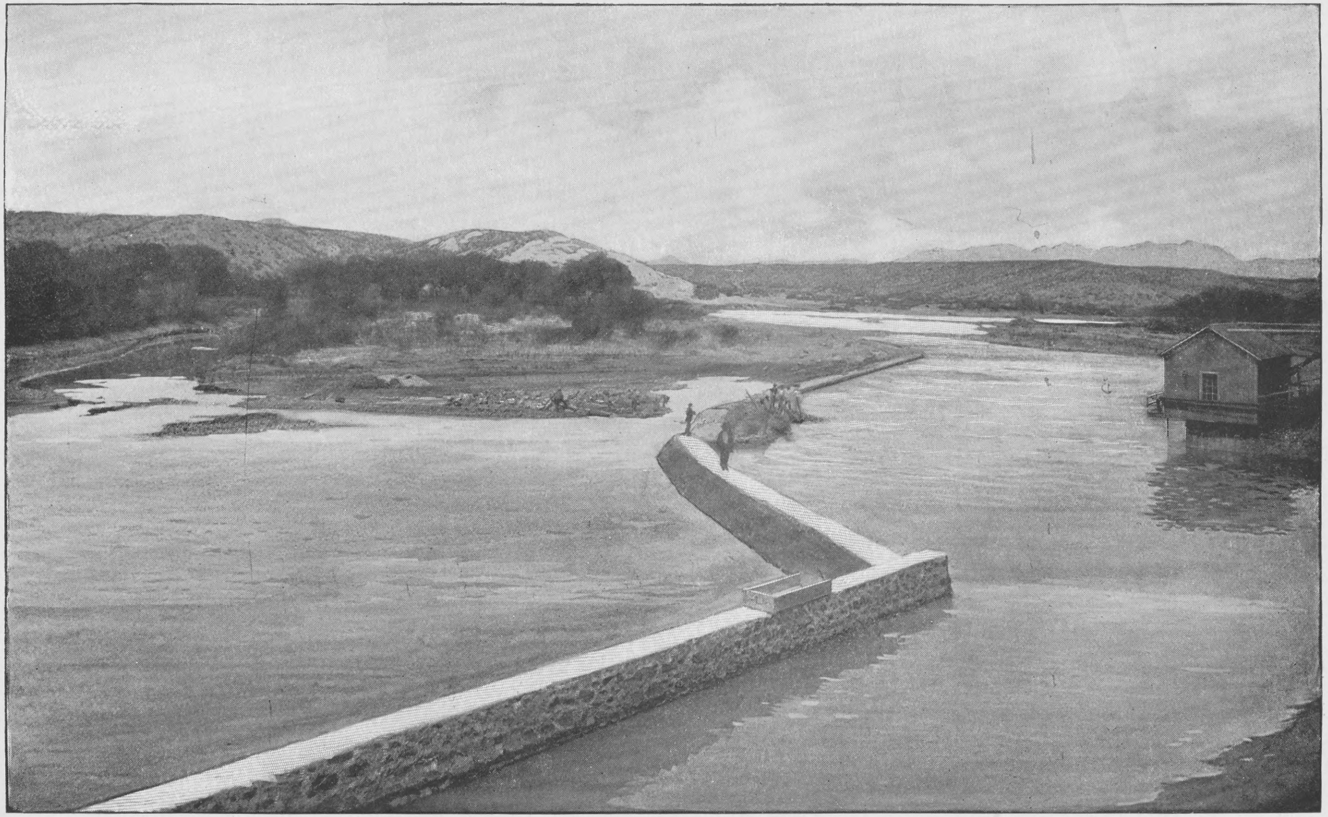
The practice of irrigation in Texas is of considerable antiquity, especially in the western end of the State, along the Rio Grande, where the early Spanish conquerors established settlements, and their descendants, the Mexicans, have maintained possession of the soil for centuries. At San Antonio are ditches whose origin is lost in local tradition, having probably been built to carry water to the grounds surrounding the missions. It is only in comparatively recent years, however, that particular attention has been drawn to the matter, and the importance of the development of the State through irrigation has been appreciated by the public. Already agriculture by means of an artificial supply of water is being practiced in nearly every portion of the State, the greatest increase in acreage being in the rice-growing districts in the southeastern quarter. The figures obtained at the Eleventh Census (1889) and Twelfth Census (1899) illustrate the rapid increase in acreage and the wide extent to which irrigation is now employed.

For most of the land water is obtained by gravity systems of ditches—that is to say, by means of channels through which the water flows from some source at a higher elevation. In many places, however, it is impossible to bring water to the surface of the ground in this way, and it must be lifted or pumped by some mechanical device. For this purpose windmills are most commonly used. West of the one-hundredth meridian north of San Antonio the cattle country of Texas stretches almost unbroken for from 200 to 500 miles. To supply water for the ranches which do not border on or include a flowing stream the windmill has become a most potent factor. In addition, a few localities, like oases, have everlasting springs that rise with surprising suddenness either from the foothills or from the baked prairies. These are in nearly all cases utilized to convert the otherwise unproductive soil into crop-bearing farms. While the old Mexican methods of irrigation are still in use in many localities, with their consequent waste of water, they have been accompanied by few disappointments or heart-burnings.

Irrigation in Texas has not escaped the booming influence of the land agent or the subtle promoter. Nearly every county in the western part of the State through which flowing streams course their way has on its maps the sinuous tracings of irrigation systems, while the secretary of state has issued hundreds of charters for systems that fortunately got no further than the charter stage. Some of the promoters, however, with the seductive phrase "modern methods," have formed companies, constructed canals costing hundreds of thousands of dollars, and sold lands, upon flattering prospectuses, to honest and would-be settlers without the slightest data of the available water supply. The collapse of many enterprises and the loss of much money have made the public timid, with the result that two amendments to the State constitution, which carried with them permission to bond certain districts, have been overwhelmingly defeated. The first was prepared in 1897, and under its terms certain districts could, by a majority vote of the landowners, issue bonds for the purpose of constructing irrigation systems. The second amendment, which was voted on in the fall of 1900, carried with it power by virtue of which the people of the Wichita and adjacent districts could issue bonds for the purpose of constructing an immense irrigation system in the Wichita Valley.

With sufficient hydrographic data, however, there was and is no occasion for disappointment; but obtaining these data is a process entirely too slow for the irrigation agent, the promoter, and the developer, and the result is marked by wrecked hopes in many localities. The year 1900, a very wet one, furnished excellent data upon which flattering prospects could be held out to prospective rice farmers, as all streams, bayous, and lakes were full of water and the rainfall was so abundant that only a small amount of artificial watering was required. Result, an excellent crop of rice, a large part of which was watered by Providence. The year 1901, however, was a striking contrast to 1900, for there was no good soaking rain from the time of the Galveston storm, September 8, 1900, until the latest sowing of 1901. The coast country was dry, water was low, and new canals were untried. No two years could emphasize more clearly the need of caution in placing dependence upon a water supply. In the latter year many of the bayous were drawn upon for an amount of fresh water that so lowered their surface level that the salt water of the lower sections backed into them and impregnated the supply. To counteract this, at some places dams have been constructed to check the inflow of sea water.

The irrigation systems of the State have been divided into the following groups: (1) The trans-Pecos systems; (2) the Pecos Valley systems; (3) the Edwards Plateau systems; (4) the systems at San Antonio and vicinity; (5) the systems along Lower Nueces River, Lower Rio Grande, and Leona River; (6) the Colorado Valley sys-



WING DAM OF EL PASO IRRIGATION COMPANY.

tems; (7) the systems north of Colorado River; and (8) the rice irrigation systems.

The two dry years of 1901 and 1902 have called attention to the necessity of irrigation in what has been heretofore called middle Texas. Farmers are realizing the efficiency of an irrigation system to be put into operation when the rainfall is not sufficient for agricultural purposes. Slowly irrigation for ordinary crops takes its way eastward in Texas. It is now on the Brazos, and another dry season will take it to the Trinity River.

In the preparation of this paper valuable assistance has been rendered by Lester G. Bugbee, instructor in history in the University of Texas; Willard H. Denis, observer at Pecos; Judge O. W. Williams, of Fort Stockton; the late S. C. Dobbins, civil engineer, and T. L. Smith, civil engineer, of Columbia. The writer has also frequently consulted Water-Supply Paper No. 13, prepared by W. F. Hutson.

TRANS-PECOS SYSTEMS.

The portion of the State west of Pecos River is commonly known as trans-Pecos Texas. It is a peculiar country, rough and mountainous, with few perennial streams. The storm waters rush out upon the lowlands and are rapidly absorbed in the sandy plains, from which the mountains rise abruptly as isolated peaks or ranges. The soil of the plains is of remarkable fertility, and when watered produces abundantly. Irrigation away from the creeks, however, is practicable only by means of storage reservoirs holding the storm waters. Reservoir sites occur in many places, and several of them have been mapped by the topographers of the Geological Survey. Trans-Pecos Texas is bounded on the west and south by the Rio Grande, from which water is at present taken for irrigation mainly in the vicinity of the Big Bend. The following irrigation systems occur in the trans-Pecos region: (1) The El Paso Valley systems; (2) the Toyah Creek systems; (3) the Fort Stockton systems; (4) the Santa Lucia systems; and (5) the Big Bend systems.

EL PASO VALLEY.

Franklin canal.—At El Paso the principal canal is that owned by the Franklin Irrigation Company. It was begun in 1889 and completed in 1891. Later the affairs of the company were placed in the hands of a receiver, and the property was bought at a receiver's sale by Thomas Worthington, of Manchester, England, the trustee for the bondholders. The canal begins 1 mile northwest of El Paso, and runs in a general southeasterly direction for 29 miles. (See fig. 1.) At the beginning its width is 30 feet, but it gradually diminishes to 15 feet at Fabens, where it returns to the Rio Grande. Water is diverted by a masonry wing dam extending diagonally up the river about 300

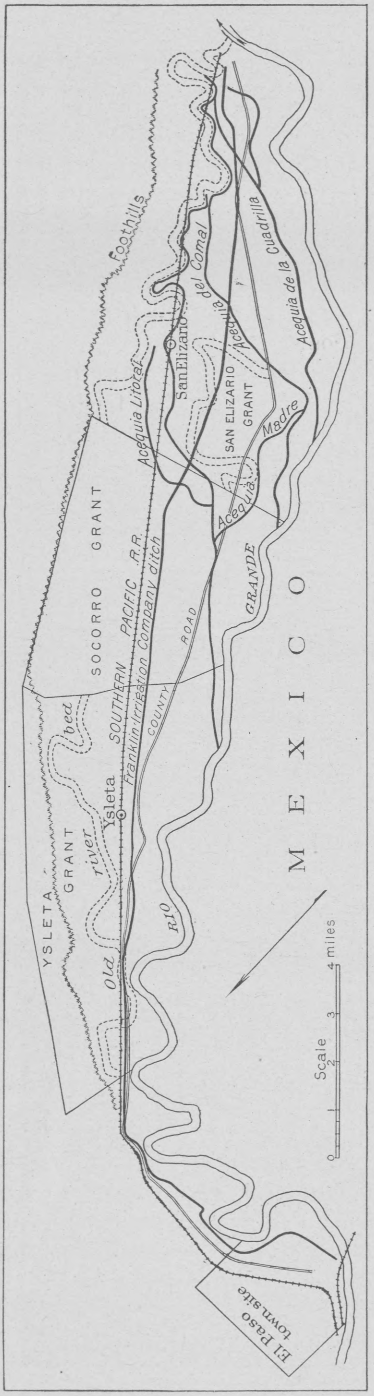


FIG. 1.—Map showing irrigation systems in El Paso Valley.

feet and about halfway across, as shown in Pl. I. The original cost was approximately $150,000, and about $70,000 has since been expended for protection from overflows and for repairs. The water rights under the new management have not yet been issued. The yearly water rental was $2 an acre. The canal was designed to cover 30,000 acres. During 1896, 3,000 acres were irrigated from it, but since that time practically no land has been served from this ditch, on account of lack of water in the Rio Grande.

Ysleta, Socorro, and San Elizario ditches.—There are three old Mexican ditches taken from the Rio Grande below El Paso, on the American side, on grants of land made to the inhabitants of Ysleta, Socorro, and San Elizario, capable of irrigating from 1,000 to 1,200 acres each. (See fig. 1.) The ditch on the Ysleta grant was taken out of the Rio Grande about 3 miles south of the present station of Ysleta (not the old town of Ysleta), and continued through the Socorro and San Elizario grants, following the banks of the old river bed after passing the present station of San Elizario. The total length of the main acequia was about 10 miles, and the two branches, the Acequia Littoral and the Acequia Madre, were 4 and 3 miles long, respectively. The Acequia del Comal took its water from the Rio Grande about 15 miles below El Paso, on the lower part of the Socorro grant. It followed the general course of the river for $2\frac{1}{2}$ miles, then ran almost due east for $3\frac{1}{2}$ miles, and finally deflected to follow the banks of the old river bed. Its total length was about 10 miles. The Acequia de la Cuadrilla took its water from the Rio Grande 2 miles below the intake of the Acequia del Comal. Its total length was about 9 miles.

These Mexican ditches are capable of irrigating about 3,000 acres, but the flow of the Rio Grande at El Paso has been so unreliable for several years that it was impossible to base any calculations upon it. A reliable storage reservoir in the mountains above El Paso would serve during its life to make the whole El Paso Valley on both sides of the river for 30 miles one of the most productive countries in the world, for it possesses an unrivaled climate and is capable of producing fruits with a flavor that easily commands for them the highest price wherever they go. The total area on the American side that could be brought into active production would be not less than 40 square miles.

Irrigation has been practiced here probably longer than in any other part of the United States. The old Spanish records show that when this pass was first reached by the exploring party of Coronado, villages of Indians were found on the Mexican side, on the site of the present town of Jaurez, and on the American side at Ysleta and below. These Indians had a system of irrigation of seeming great antiquity, which has been followed by the descendants of the aborigines and their conquerors for three hundred and fifty years.

During the spring of 1897 the large canal was damaged by the flood that submerged so large a portion of the town of El Paso. This flood reached its greatest height on May 26, and quickly subsided. The banks were badly cut, and in some places the canal was completely obliterated. The truck gardens and orchards near the city were flooded and damaged, a layer of mud about 3 inches thick being deposited over the surface. It was noticeable that while most trees withstood the flooding comparatively well, the peach trees were almost uniformly killed. Fortunately for the farmers lower down, a portion of the river cut for itself a new channel, curving inward, crossing the canal, and then recrossing it at the last point at which the banks were damaged. In this way they have been supplied with water and are able to save their crops, which otherwise would be ruined.

TOYAH CREEK.

Toyah Creek rises in natural springs about 40 miles southwest of Pecos. These springs are mainly in section 256, patented by the State of Texas to Antonio Ball. They are in a flat valley, hemmed in by a horseshoe curve of the Davis Mountains. About 3 miles northwest is Phantom Lake. It is stated by close observers that the waters of the creek and lake are of the same composition and general character, and it is probable that the latter is on the underground stream that issues from the earth in the Toyah Springs.

The largest of the Toyah Springs is oval shaped, and is about 100 feet long by 60 feet broad. Its water level in the spring varies with the condition of the weeds and long grass, and also with the weather. The discharge as measured by the writer on September 5, 1900, was 46 second-feet. A large percentage of the water is deflected

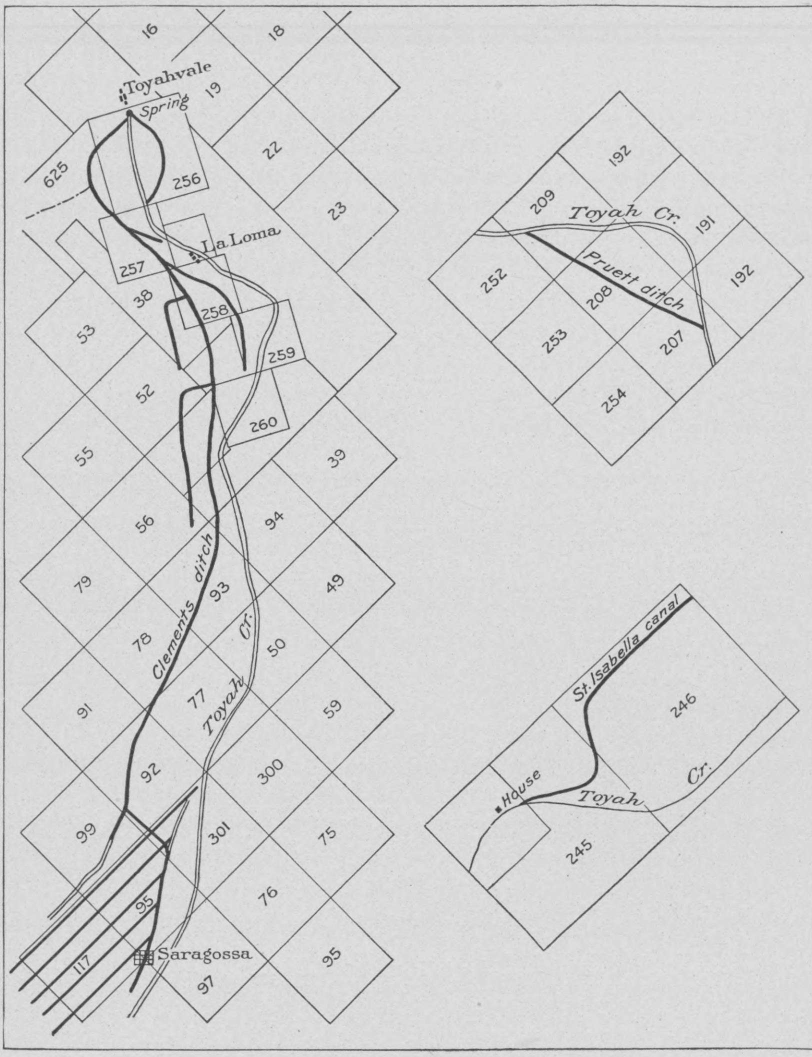


FIG. 2.—Map showing Toyah Creek irrigation systems.

into the ditch of Toyah Creek Irrigation Company. The flow of the spring is equal to about 8 heads, a head being defined as the amount of water that flows through an opening 1 foot square, the upper edge of the opening being 4 inches below the water surface. There is an unverified and hazy tradition that the flow once amounted to 12 heads, but this is seriously doubted.

For several miles the creek skirts the foothills of the Davis Mountains, and in addition to the well-known springs mentioned is fed by small invisible springs and by seepage. It empties into Toyah Lake, a large alkali flat depression about 35 miles from Toyahvale and about 12 miles south of Pecos.

In all there are five ditches taken out of Toyah Creek: (1) The Clements or Murphy, 9 miles long, taken out of Toyah Spring, on the south side, and irrigating about 1,500 acres; (2) the Giffin, 1 mile long, taken out of Toyah Creek, on the north side, and irrigating about 400 acres; (3) the Saragossa, 2 miles long, taken out on the south side of the creek, about 6 miles below Toyah Spring, and irrigating 1,500 acres (this is included in the Clements system); (4) the St. Isabella ditch, which irrigates about 700 acres and is 2 miles long, being taken out on the north side of the creek, 19 miles below Toyah Spring; and (5) the Pruett ditch, 2 miles long, headgate 26 miles below Toyah Spring, on the south side, which irrigates about 300 acres. The location of the ditches is shown in fig. 2. The crops raised are mostly corn, wheat, Kafir corn, and sweet potatoes. From Toyahvale to Saragossa the irrigation has been very efficient. A half mile above Saragossa, on the main Saragossa ditch, is Clements's grain and flour mill, an adobe and timber structure, at which there is a fall of 12 feet.

The main irrigation ditch leading from the largest of the Toyah springs (now known as the Clements or Murphy ditch) was projected as early as 1875, but the ditches of the Saragossa and the Toyah Creek companies were chartered in 1875 and 1876. Afterwards the companies passed through various ownerships and changes until 1894, when Mr. E. Clements obtained all the rights and ownership of the Saragossa Company ditch, and in 1895 he obtained a controlling interest in the Toyah Creek ditch. The Saragossa ditch was taken out of Toyah Creek about 6¼ miles below the Toyah Springs and about 1¾ miles above the town of Saragossa. Both ditches are now operated under the Clements management, a lateral connecting them. The original Saragossa ditch was taken out probably as early as 1869, at a point where the bed of the creek ended in rather swampy lands. These lands are now in the Saragossa farm. From the best evidence obtainable the flow of the Saragossa Spring was about 15 second-feet, and it was the largest affluent of Toyah Creek below section 256.

Toyahvale is about an eighth of a mile west of the Toyah Springs; La Loma is about 1 mile below the head spring, on the right bank; India (known as Brogado P. O.) is about 4 miles below the Toyah Springs, on the right bank; while Saragossa is 9 miles below the head spring, on the right bank of the creek.

FORT STOCKTON.

Comanche Creek rises near Fort Stockton, in a clear and bold spring. In 1899 its flow, as determined by measurement, was 70 second-feet. The waters of the creek were first used for irrigation in 1868, when Cæsario Torres irrigated land belonging to Gen. John Hatch and others. In 1870 the United States Government irrigated about 100 acres, most of which was used for a garden for the post.

In fig. 3 are shown four irrigation ditches taken out of the creek, two on the right or east side and two on the left or west side.

Garza ditch and Comanche Creek Irrigation Company ditch.—The ditches on the right side of Comanche Creek are known as the Garza ditch and the Comanche Creek Irrigation Company's ditch, both of which are owned by the Southwestern Irrigation Company. The former is taken out about 3 miles and the latter $3\frac{1}{4}$ miles below

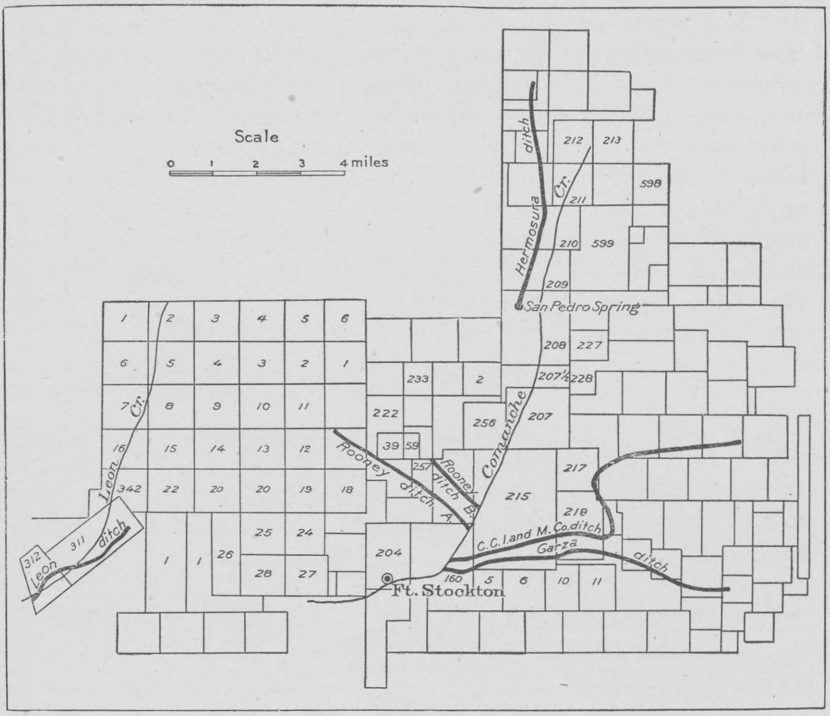


FIG. 3.—Map showing Fort Stockton irrigation systems.

Fort Stockton. A loose dam, made of cottonwood logs and turf, raises the water into the Garza ditch, which is 6 miles long and is used to convey water to cattle ranches. From 600 to 800 acres are irrigated from the lowest (Comanche Creek Irrigation Company) ditch, 400 acres being in alfalfa.

Rooney ditches.—Two ditches, known as the Rooney ditches, and marked A and B in fig. 3, are taken out on the left side of the creek. They were constructed in 1876 and 1877. Ditch A is about 4 miles long, and is taken out about a half mile below the head of the Garza ditch. The Rooney ditches can irrigate 6,000 acres. In 1900 they actually irrigated 1,360 acres, 900 acres being in corn, 400 acres in cotton, and 60 acres in alfalfa. On ditch A is located the mill belonging to Rooney & Butts, of Fort Stockton. The fall at the gin is 12 feet, and 12 horsepower is developed by a 24-inch Leffel turbine.

Hermosura ditch.—The Hermosura ditch, owned by J. H. Crawford, is 7 miles east of Fort Stockton and receives its waters from the San Pedro Spring, which is in section 208 of the Texas land office map. The flow of the spring is about 4 second-feet, and from it Mr. Crawford irrigates 160 acres of land.

Seven miles west of Fort Stockton Mrs. Royall irrigates 260 acres from the Leon Spring.

SANTA LUCIA.

The Santa Rosa Spring is in section 68 of the Texas land office map. It comes out in a bold stream of about 10 second-feet volume, and flows in the ditch constructed for its control. It is 4½ miles north of the post-office at Santa Lucia, the office being located at the home of Thomas L. Ray, the largest user of the Santa Rosa water for irrigation purposes. The water is under the control of the Pecos River Company, and each irrigator pays 50 cents per year per acre for sufficient for his crops. Mr. Ray planted cottonwoods along the ditches, and now his farm is bordered on the north and west sides by stately trees that can be seen for 20 miles. He lives in section 104, and irrigates 100 acres. Mr. Levi A. Scott lives 2 miles north of Santa Lucia, and irrigates 60 acres from the Santa Rosa (spring) ditch. The crop raised is mostly alfalfa, and when visited in June, 1900, all kinds of stock were being fattened upon green alfalfa. In addition to the alfalfa, Mr. Ray has a thriving orchard of peach trees just coming into thrifty bearing. The Santa Lucia systems are shown in the map, fig. 5.

BIG BEND.

The land along the Rio Grande in the Big Bend is very rich and will raise any crop that grows in Texas. Its yield is enormous, as many as 80 bushels of corn and 50 bushels of wheat being grown to the acre. Irrigation on a small scale is practiced extensively.

Candelaria ditch.—At Candelaria, a Mexican settlement on the Rio Grande about 45 miles from Shafter, there is an irrigation ditch 4 miles long, which was built by the Mexicans. It is fed by Coyote Creek, and irrigates about 200 acres. The Rio Grande is generally dry at this point during the irrigation season, but when it flows part of its waters are deflected into the Candelaria ditch.

Dawson system.—At Shafter Mr. G. S. Dawson has two tanks that are filled from a strong spring. Small ditches, or acequias, lead from the tanks and irrigate his farm, orchard, and garden. The land not in orchard or garden is sowed in wheat, which is cut green to serve for feed, and the land is then plowed and planted in corn and beans.

Del Rosa ditch.—The Rio Rosa ditch is 6 miles long, 6 feet wide, and from 2 to 4 feet deep. It was built about 1880. A low dam of loose rock, 1 or 2 feet high, is constructed across the Rio Grande, and serves to irrigate about every other year 1,200 acres.

Palvo Irrigation Company ditch.—About 10 miles below Presidio the Palvo Irrigation Company has a ditch 5 miles long, 6 feet wide, and 6 feet deep. Water is obtained by means of a dam of loose rock, 500 feet long and from 2 to 4 feet high, which was constructed across the Rio Grande in 1877. Two miles above Presidio the Rio Concho of Mexico enters the Rio Grande, affording an abundant supply for this ditch. Above the mouth of the Rio Concho the flow of the Rio Grande is unreliable.

Mulato canal.—Opposite the Palvo canal, on the Mexican side, is the Mulato canal, in the State of Chihuahua. This canal shows what can be done by irrigation in the Big Bend. It is 6 miles long, 10 feet wide, 4 feet deep, and supports 1,000 persons. It is taken out of the Rio Grande a short distance below the Palvo dam, and reenters the river at the Mexican village of Mulato, below Palvo.

Ernst and Lindsey systems.—Near Boquillas, on the Rio Grande, in Brewster County, there are two small irrigation plants which take their water from Tornillo Creek, which is dry most of the year, but affords excellent opportunities for impounding. Mr. A. Ernst owns a ditch 900 feet long, 4 feet wide, and 3 feet deep, which was constructed in the early part of 1901, on the east side of the creek. The soil here is sandy and of good productive possibilities. Twenty acres, in corn, cotton, and beans, were irrigated this year (1902). The plant of D. E. Lindsey is on the west side of the creek. The ditch was constructed in 1898. It is 1,500 feet long, 3 feet wide, and 2 feet deep. The earth dam across the creek is 400 feet long and 6 feet high. Thirty acres, in beans and corn, are cultivated at this plant.

Ditches along Alamo and Leoncito creeks.—Two ditches have been taken out of Alamo Creek, in Brewster County. The first of these, taken out in 1880, is 2 miles long, 3 feet wide, and irrigates 250 acres of corn, beans, wheat, and sorghum. The water is deflected into the ditch by a dirt dam 40 feet long and 4 feet high. A ditch has also been taken from Leoncito Creek. Its length is one-fourth of a mile, its width 1 foot. It irrigates 3 acres of alfalfa. Two other small ditches, irrigating about 3 acres each, derive their water from small springs.

Pool system.—A few miles from Shafter, on the ranch of J. R. Pool, 5 acres, in vegetables and fruits, are irrigated. The water is derived from springs, and the peaches produced are of excellent quality and abundant quantity.

Hosier Brothers system.—The Hosier Brothers, near Dryden, have two small ditches, from which 24 acres are irrigated. The larger one is three-fourths of a mile long. It was built in 1898 and 1899, takes its water from a spring, and irrigates 19 acres in corn. The smaller ditch was built in 1894, is one-fourth of a mile long, takes its water from Arocha Spring Creek, and irrigates 5 acres of sweet potatoes, melons, and vegetables.

Ditches in Jeff Davis County.—In Jeff Davis County, along Limbia Creek, several small gardens and farms, aggregating nearly 100 acres, are irrigated.

Templeton system.—Thirteen miles northwest of Alpine and 15 miles southeast of Fort Davis, in the county of Jeff Davis, there is an irrigated system on the Templeton ranch. Two natural springs from the side of a mountain supply the water to irrigate an 18-acre orchard containing about 2,000 fruit trees, consisting of apples, peaches, plums, pears, apricots, quince, and almond. The two springs irrigate separate pieces of ground. The one near the residence supplies water for domestic use, irrigates about 2 acres, and waters the domestic stock. In connection with this is a cement tank, having a capacity of 11,000 gallons, which is supplied by pipes that lead from the spring and fill it in about thirty-six hours. This amounts to about one-third the flow of the spring. The larger spring irrigates directly 15 acres without the intervention of a reservoir.

Two miles above this place is located a field of about 30 acres which is supplied by one or more springs. No ditches are used, but the forage crops, consisting of alfalfa, Johnson grass, and cane, are subirrigated, and when not used for pasture the field produces three or four crops each year.

PECOS VALLEY SYSTEMS.

Pecos River rises in the northeastern part of New Mexico and flows in a general southerly direction through the southeastern part of that Territory, crossing the western prolongation of Texas and finally entering the Rio Grande at about the lower third of the length of that stream. It is supplied to a considerable extent by water from large springs in the limestone rocks of the region, of which Roswell is now the principal town. These maintain the perennial flow of the river, the run-off from the catchment basin being irregular in character and diminishing at times to relatively small amounts.

Large irrigation works have been constructed in the vicinity of Roswell, which utilize the greater part of the summer flow of the river so that during the dry season of the year little water crosses the Texas line. Large storage reservoirs have been created both at Roswell and above Carlsbad. Between Carlsbad and the Texas State line there are several reenforcing springs. The water that flows in the stream is largely derived from the seepage of irrigated lands above, and is often heavily charged with alkaline salts. Irrigation canals have, however, been constructed along the valley in Texas, principally near the town of Pecos, at the crossing of the Texas and Pacific Railroad. The valley is fertile, and where properly irrigated large crops are produced.

MARGUERETTA CANAL.

The most important irrigation system along the river in Texas is the one about 50 miles from the New Mexico line known as the Margueretta canal system (see fig. 4). It was begun in 1887 by the Pioneer Canal Company, which afterwards consolidated with the Margueretta Canal Company, which now owns the whole system. Water is diverted by means of a brush dam, it being deemed impracticable to build a masonry structure in the sandy river bed. The dam is 250 feet long and 5 feet high. The head gate is shown in Pl. II, *A*. As shown in fig. 4, the canal is taken out of the west side of the river, runs in a southwesterly direction for a distance of 3 miles, crosses the river in a flume (shown in Pl. III), and then runs in a general easterly

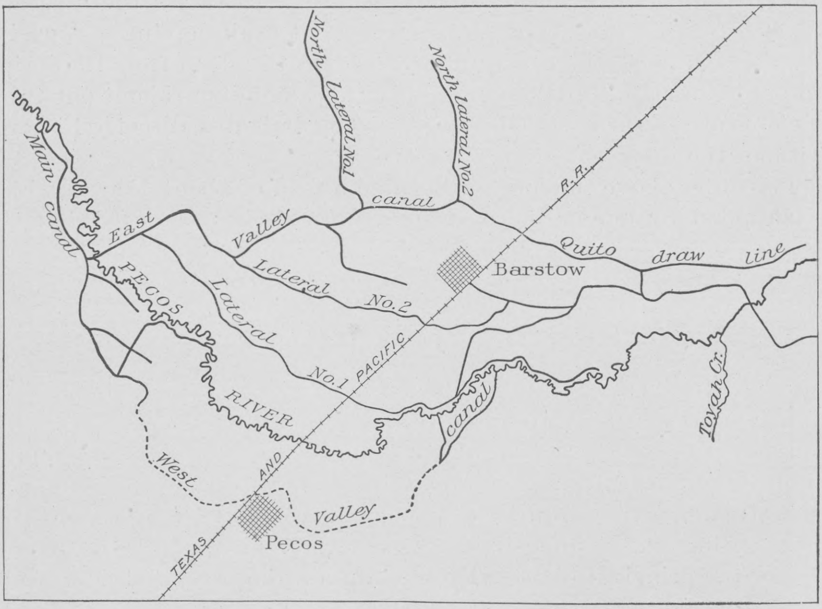
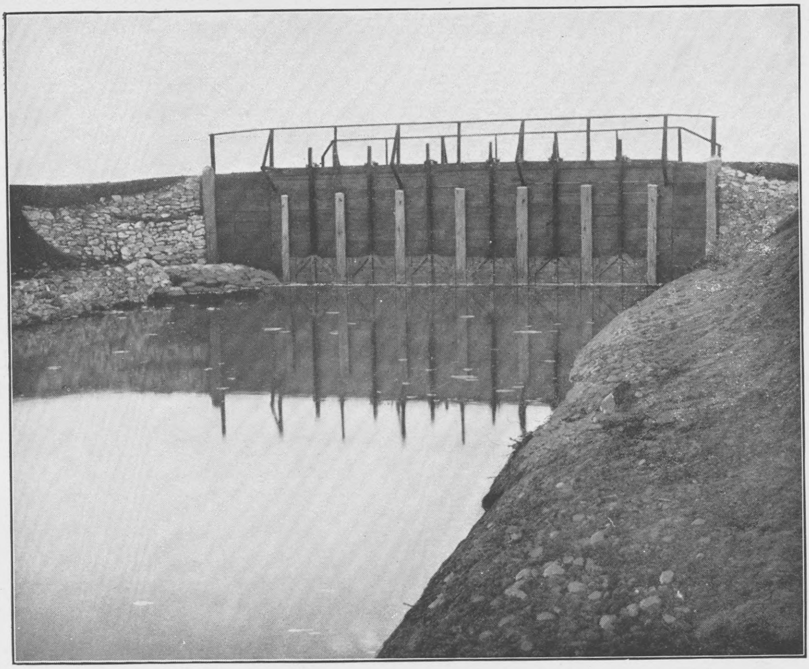


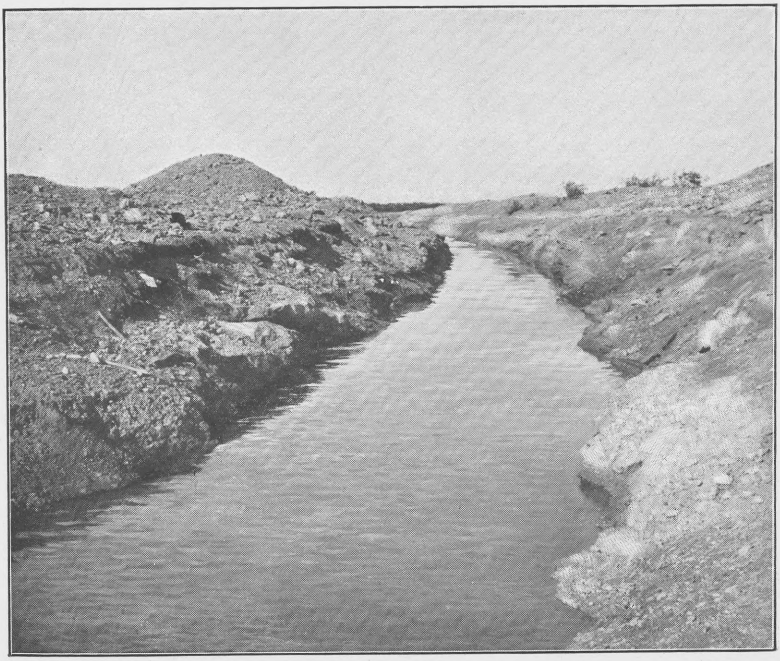
FIG. 4.—Map of Margueretta canal system.

direction for 12 miles. There is also a branch continuing down the west bank for a considerable distance, being the main part of the old Pioneer canal and now known as the West Valley canal, a view of which is shown in Pl. II, *B*. Thirty current-meter measurements during 1900 show that this ditch carries an average of 12 second-feet of water. The dimensions of the main ditch are: Top width, 30 feet; bottom width, 18 feet; depth of water, $4\frac{1}{2}$ feet. There are three principal laterals, with bottom widths of 12, 6, and 8 feet, respectively. In Pl. IV, *A* and *B*, are shown a sluice gate and a measuring weir used on the canal.

The canal was first used in 1889, and the extent of land irrigated



A. HEADGATE OF MARGUERETTA CANAL.



B. ROCK CUT IN CURVE OF WEST VALLEY DITCH, MARGUERETTA CANAL.

MARGUERETTA FLUME ACROSS PECOS RIVER.

by it is steadily increasing. The total cost of the system was more than $150,000, and it is designed to cover about 40,000 acres, only 6,000 of which are, however, yet under cultivation. The water rights are sold at $10 an acre, a permanent right guaranteeing 25 miners' inches of water to the acre. The annual rental is $1 and $1.50 for each acre served with water. The principal crop is cotton, of which there are about 3,500 acres. The other crops cultivated are alfalfa, sugar beets, and all kinds of forage plants, fruits, and vegetables. Sugar beets tested in 1896 showed between 14 and 20 per cent of saccharine matter. Peaches, apples, and grapes do well. Cotton averages 500 pounds of lint to the acre. The annual rainfall is about 12 inches. Owing to the high elevation (2,700 feet) the seasons are much later than in most of the irrigated districts of the State.

The enterprise seems to have been conducted with energy and care, the canals and head gates are well planned and well built, and altogether the scene about Barstow, the center of the irrigated portion, has a general air of healthy growth and prosperity that is very pleasing to the eye after the many miles of desert scenery between there and El Paso. There are, however, a number of problems that must be solved before agriculture will be everywhere successful. Much of the land is impregnated with what is known as alkali. At first this does not prove troublesome, but after a few years of cultivation it may be brought to the surface by injudicious treatment, and the river water used in irrigation continually adds to the supply of this mineral matter. The only remedy so far applied is drainage, which is as important in its way as irrigation. The land is nearly level, and considerable care will be required to provide means by which the accumulated alkali can be washed from the soil.

One of the principal crops is alfalfa, which sells at $8 a ton on the cars at Pecos and $10 a ton retail. Alfalfa (*Medicago sativa*) will grow on almost any land, under almost any conditions, but satisfactory results can be expected only on a naturally deep, loose, porous soil, preferably deep sand, underlain with gravel, so that good drainage is assured.

PECOS RIVER IRRIGATION COMPANY.

About 28 miles below Pecos is the head gate of the canal of the Pecos River Irrigation Company, on the west side of the river, running in a general southeasterly direction for 12 miles. It is the oldest ditch on the river in Texas, having been built in 1875 and 1876. It was enlarged in 1889 and used again in 1890, but has never been entirely completed in its enlarged condition. It takes all its water by means of a brush-and-stone dam about 60 feet long and from 5 to 6 feet high. The total cost of the undertaking was about $35,000. It was designed to irrigate 20,000 acres, but only 100 acres were irrigated in 1901. The water supply was very short for several years, especially in 1892, 1893, 1894, and 1898, after the dam at Carlsbad, N. Mex., was completed. The flow has increased since then, but the river becomes quite low and the water bitter in March and April of each year. The soils and crops raised are similar to those at Pecos and at Barstow, but as at times only 15 second-feet of water are permitted to pass Pecos, the supply and quality are entirely inadequate to meet the demands.

GRAND FALLS.

The Grand Falls Irrigation and Improvement Company takes out a canal 4 miles below the head gates of the one last described, but on the opposite side of the river. It was begun in 1896, and 16 miles of it are finished. It is supplied by a brush-and-stone dam across the

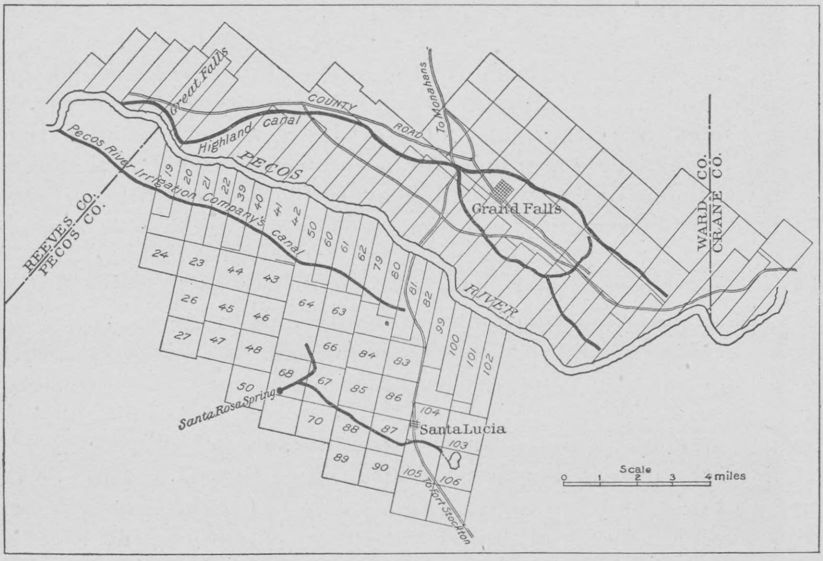
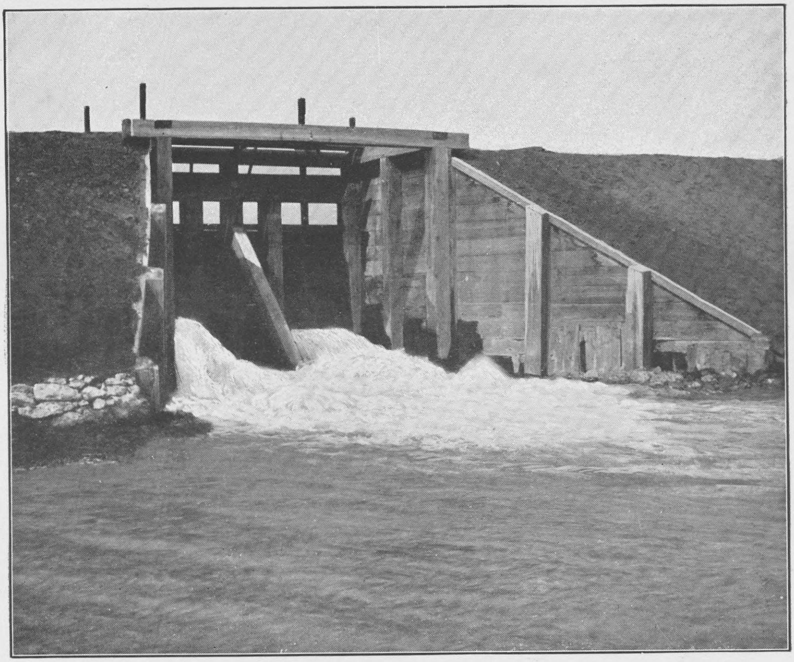
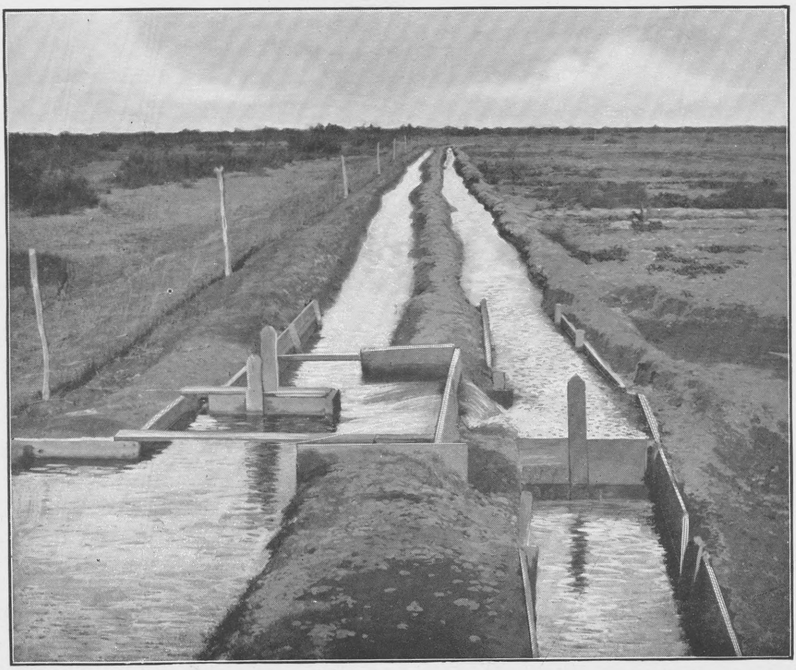


FIG. 5.—Map of Grand Falls and Santa Lucia irrigation systems.

river, 100 feet long and 7 feet high. The water rights are valued at $15 an acre; the annual assessment is $1.25 an acre. The company has completed an excellent system of canals in one of the most fertile valleys in Texas (see fig. 5), but the enterprise, like that of the Pecos River Irrigation Company, left two factors out of its calculations or gave them too little weight—i. e., the minimum flow of the river and the amount of alkali it carries at low stages. Both factors prove almost conclusively that only alfalfa can be raised on either side of the river near Grand Falls. The brackish condition of the water will affect the young alfalfa, but after it gets stronger it can stand it and water can be applied at will. By judicious management a small amount of alfalfa can be produced in paying quantities, notwithstanding the alkali in the water. The Pecos and Grand Falls systems have fallen far below expectations.



A. SLUICE GATE USED ON MARGUERETTA CANAL.



B. MEASURING WEIR ADOPTED BY PIONEER CANAL COMPANY.

EDWARDS PLATEAU SYSTEMS.

The Edwards Plateau comprises the region bounded by Colorado River on the north and northeast, by the International and Great Northern and the Southern Pacific railroads, and by Pecos River. The systems treated under this section are those included in the plateau and its foothills, including, in whole or in part, the systems in the counties of Valverde, Kinney, Edwards, Kimble, Menard, San Saba, and Kerr. From the foothills of the plateau numerous large springs gush forth from the limestone rocks, and many of these have been utilized for water-power and irrigation purposes. Springs occur at Lampasas (the Hancock and Hanna springs; volume, 15 second-feet); at Walton's ranch, near Bartlett; at Mormon Springs (volume, 10 second-feet), on the banks of the Colorado, 1 mile above the Austin dam; at Barton Springs, 1½ miles southwest of Austin (with a volume varying from 18 to 70 second-feet, the average being 30 second-feet); at San Marcos, forming San Marcos River (minimum volume, 70 second-feet); at New Braunfels (minimum volume, 300 second-feet), forming Comal River; at San Antonio, with a volume varying from 9 to 125 second-feet; at Uvalde, with a volume varying from 0 to 15 second-feet; at Brackettville (the Las Moras, with a minimum volume of 21 second-feet); at Del Rio, in the San Felipe Springs and Creek, with a minimum volume of 60 second-feet; along Upper Nueces River, in the Edwards Plateau; the Kickapoo Spring, in Tom Green County, etc. The systems treated here are those at Del Rio, including Cienagas Creek; those along Mud and Los Moras creeks; those along the Upper Nueces; those near Menardville; and those in Kerr, Kimble, and Edwards counties.

DEL RIO.

At Del Rio is one of the most effective and successful irrigation systems in Texas. A map of it is shown in fig. 6. The water is supplied from San Felipe Creek, a short stream formed by four large springs, about 1 mile east of the town, within a fourth of a mile of one another. In the 4½ miles from the springs to the Rio Grande the fall of the stream is 62 feet, thus furnishing an excellent water power for manufacturing purposes. Four ditches have been taken out, two of them for irrigation. They are supplied with water by means of two permanent masonry dams 65 and 150 feet in length, respectively, and each 8 feet high. The smaller dam, shown in Pl. V, *B*, is nearest the springs, and is the starting point of the San Felipe ditch, shown in Pl. V, *A*.

The first ditch was started in 1868 by James H. Taylor and others. The company purchased about 6,000 acres of land, including Cienagas and San Felipe creeks. In 1869 several hundred acres were irrigated from this ditch. The second ditch was taken out in 1869, with a capacity to serve 1,600 acres. The third was started in 1873; 2½ miles were built in 1874, and it was widened and completed in 1875. The ditches are now owned by the San Felipe Agricultural, Mechanical, and Irrigation Company, the shares in which are held by owners of the land commanded by the ditches. The total cost of the ditches was about $25,000, and the annual cost of maintaining them is about 50 cents per acre per annum. The main ditches measure about 4½ miles in length and are 10 feet wide at the top, have perpendicular sides, and carry about 2 feet of water. The laterals are four in number, with an average width of 4 feet and a total length of 24½ miles, making the total length of the ditches 30 miles. The area irrigated is 3,600 acres (in meadow, cotton, corn, gardens, orchards,

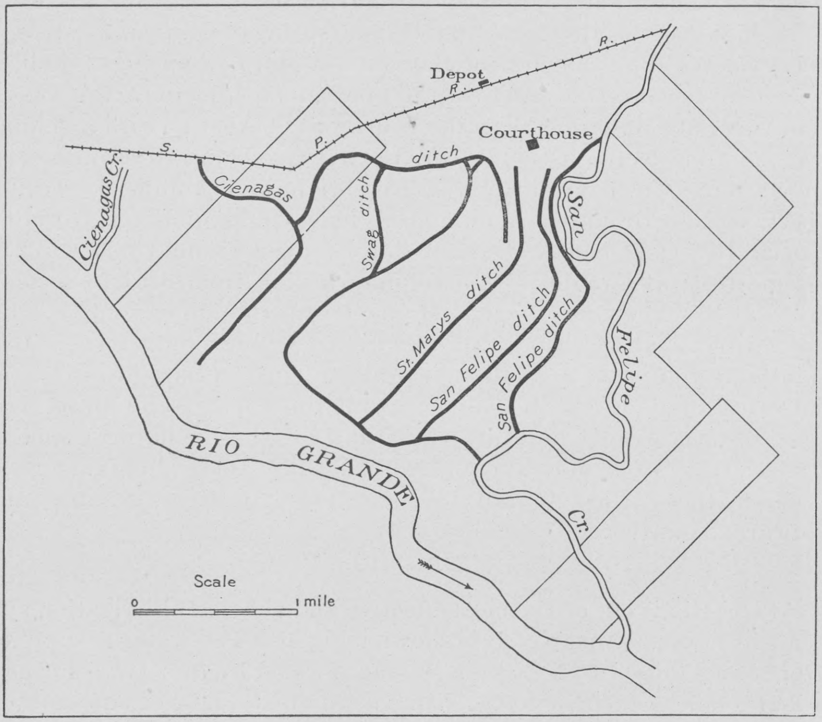
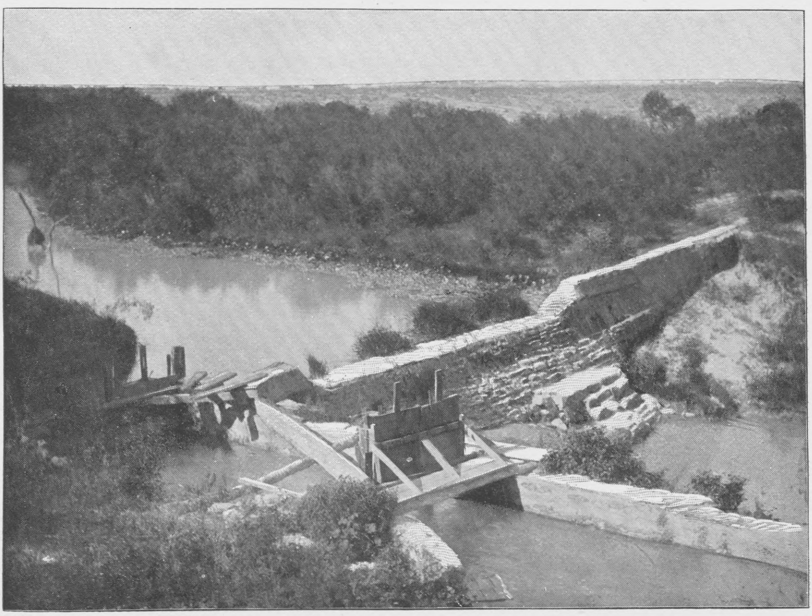


FIG. 6.—Map of Del Rio irrigation system.

and vineyards), although 5,000 acres can be irrigated. All kinds of fruits and vegetables are grown in profusion. On June 15 of this year (1902) melons, plums, and apples were ripe. The impression made on the traveler who comes from the droughty and sun-scorched plains is not soon forgotten. This cultivated tract has been so isolated from the rest of the agricultural world that none of the diseases which so reduce the profits of the grape and fruit grower elsewhere have yet been introduced. Grapes produce from 6,000 to 10,000 pounds to the acre, and are mostly made into wine, the yield of which is from 10 to 16 barrels to the acre.

A. DAM SUPPLYING SAN FELIPE DITCH AT DEL RIO.



B. DAM SUPPLYING MADRE DITCH AT DEL RIO.

CIENAGAS CREEK.

Cienagas Creek rises in the Cienagas Spring, in section 179, about 3 miles west of Del Rio. A dam 690 feet long and 25 feet high was constructed across the creek in 1875. This deflected the water into a ditch that skirted the foothills to the west, and then turned toward the east, after crossing the tracks of the Southern Pacific Railroad, as shown in fig. 7. The ditch is 3⅛ miles long, 6 feet wide, and 4 feet deep. The flow is sufficient to irrigate 800 acres. The principal crop is Johnson grass, which is raised for hay. The year 1900 was so wet

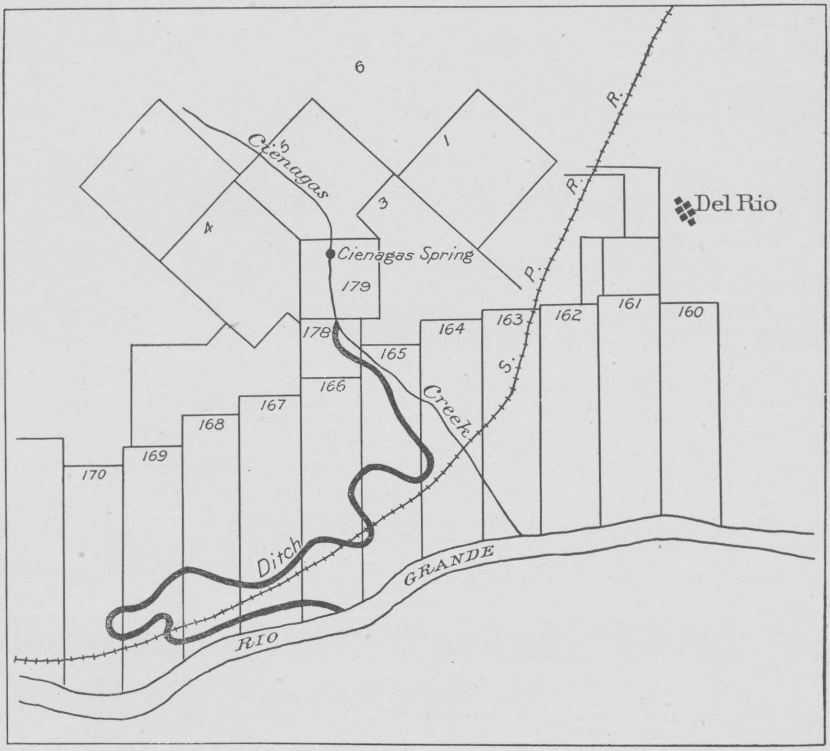


FIG. 7.—Map of Cienagas Creek irrigation system.

all over Texas that no irrigation was needed to produce an excellent hay crop. The hay farms lie along the Southern Pacific Railroad, between it and the Rio Grande. The yield in 1900 was 5 tons to the acre.

MUD CREEK.

Mud Creek, which is about halfway between Las Moras and San Felipe creeks, has had a varied history. Several attempts have been made to utilize its waters for irrigation purposes. The creek rises in large springs about 7 miles north of the crossing of the Southern

Pacific Railroad. At one time there was a dam across the stream just below the springs which backed the water over the springs, and it was claimed that this was one of the causes of the stream going dry. The dam was finally blown out, but the creek did not regain its former flow until the spring of 1900. It was practically dry from 1893

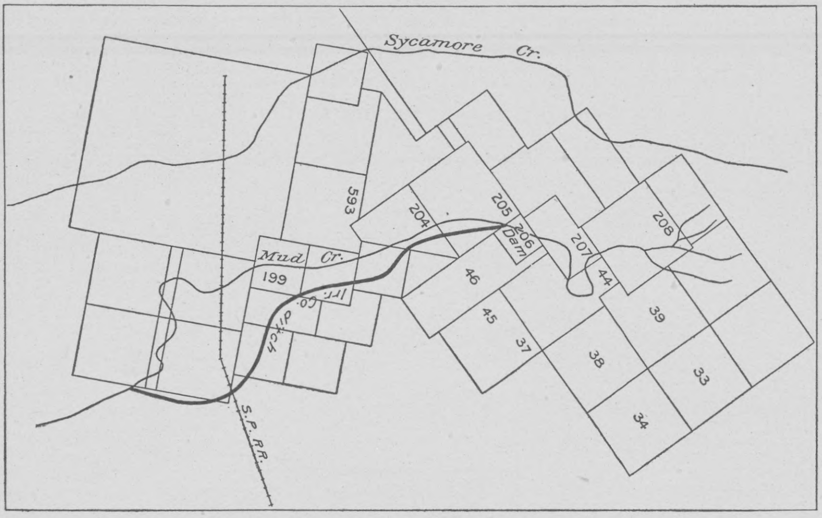


FIG. 8.—Map of Mud Creek irrigation system

to 1899. Its revival was simultaneous with the revival of the Leona and San Antonio rivers. A ditch, shown in fig. 8, is taken out of the creek on its west side 3 miles above the railroad, and in 1900 about 400 acres were irrigated from it.

LAS MORAS CREEK.

Las Moras Creek rises in large springs near Brackett. The flow in 1895 was 21 second-feet, and in 1900 it was 51 second-feet. The waters of the creek are used for irrigating farms and gardens within 10 miles of Brackett.

Government ditch.—The ditch nearest to Brackett, shown in fig. 9, is the property of the Government, being used by the Seminole Negro Indians, who live on the Fort Clark Reservation. It is on the west side of the creek, and is about 1 mile long, 5 feet wide, and 1 foot deep.

Indelkofer-Gilder ditch.—The Indelkofer-Gilder ditch, also on the west side of the creek, is taken out 1 mile below the intake of the Seminole ditch. Its dimensions are: Length, 600 feet; width, 4 feet, and depth, 1 foot; 15 acres are irrigated from it.

McGovern ditch.—The McGovern ditch, from which 8 acres are irrigated, is taken out on the east side a short distance above the intake of the Indelkofer-Gilder ditch. Its length is 600 yards, depth 1 foot, and width 5 feet.

Smith and Stratton ditches.—About 6 miles below Brackett two ditches—the Smith and the Stratton—are taken out, one on the west and the other on the east side of the creek. The Smith ditch is 600 feet long, 4 feet wide, and 1 foot deep, and irrigates from 6 to 10 acres of garden. The Stratton ditch is 3 miles long, 8 feet wide, and 1 foot deep, and irrigates a hay farm of 250 acres below the Southern Pacific Railroad. In March, 1902, through litigation, Judge Stratton lost part control of the ditch which bears his name, and he therefore abandoned it and installed a pumping plant on the Las Moras. This

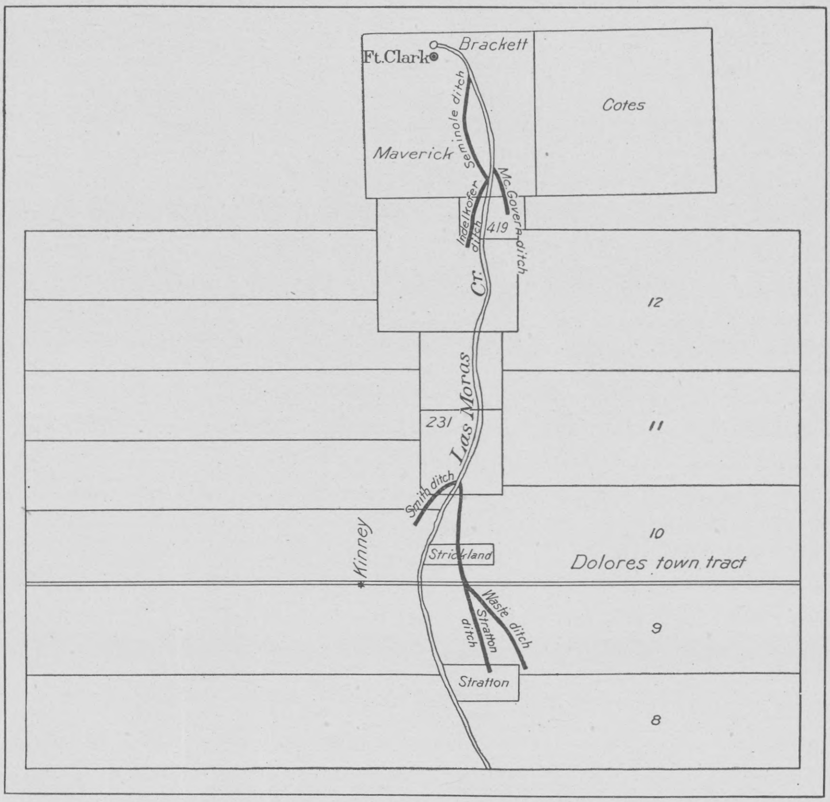


FIG. 9.—Map of Las Moras Creek irrigation systems.

plant can readily be seen from the Southern Pacific trains as they near the bridge on the Las Moras. The machinery consists of a 40-horsepower Ames steam engine, which operates an 8-inch Gould centrifugal pump against a lift which varies from 17 to 20 feet. Eagle Pass coal is used for fuel, and it requires 2,500 pounds for a complete day's run. The capacity of the plant is 4,750 minute-gallons, and in very dry seasons it exhausts the twenty-four hours' impounded flow of the Las Moras in two and a half hours. A small dam is constructed across the stream, which forms a reservoir in the channel, and is allowed to impound the water in irrigation season for twenty-four hours. The water is delivered into a flume 15 by 30 inches, 2,000 feet long, which carries it to the highest point of the land. Johnson grass is the main crop, and three crops are made each season, averaging 2 tons to the acre, which in August, 1902, was selling for $14 a ton. This is somewhat higher than usual, but it never sold for less than $11 a ton.

SAN SABA VALLEY.

The San Saba River rises in springs 1½ and 3 miles above Fort McKavett. The total flow of these at the crossing a mile below town was found on August 14, 1902, to be 13 second-feet. There are in all eleven different irrigation systems in Menard County that take their water from the river or the springs that feed it. These are the Ball, Perry, Byers, Dickinson, Striegler, Spitgarber, Coghlan, Noyes, Sieker, Kitchen, and Vanderstücken.

Ball system.—The plant of Tom Ball is north of Fort McKavett and takes its water from the San Saba by means of a pump run by a 20-horsepower steam engine. It is intended to irrigate 50 acres.

Perry system.—Seven miles east of Fort McKavett, on the south side of the river, W. J. Perry irrigates 30 acres from the Sheen spring, which comes out of the foothills in a flow of 1 second-foot. This system has been in operation a long time, and double the acreage could be brought under irrigation.

Spitgarber and Coghlan systems.—At the Spitgarber ranch, 6 miles above Menardville, there is a bold spring flowing out of the foothills. A ditch taps this spring and irrigates 20 acres. One mile above the Spitgarber ranch, on the Coghlan ranch, occurs another spring. A ditch taps the outflow of this spring and irrigates 40 acres.

Byers systems.—Twelve miles above Menardville is Byers's vineyard. The dam is almost as unique in construction as that of Captain Sieker. Into the rock bottom holes were drilled across the river and small iron posts were inserted. An iron brace was attached to each post, the other end of the brace fitting a hole drilled into the rock bottom. A plank was attached to the upper side of each post and adjusted to fit the configuration of the river bed. On the top of this bottom plank another plank was placed and attached to the posts. The race was blasted out of the solid rock on the north side of the river. Two stone piers were built up to form supports for the axis of the undershot water wheel. To the wheel are attached buckets which carry a certain amount of water to the level above, and in addition the wheel is made to operate a pump which reinforces the flow from the buckets. This plant irrigates a vineyard, the fruit of which is converted into wine. A half mile below this vineyard is the plant of the younger Byers, which is similar to that just described.

Clear Creek systems.—Clear Creek, 3 miles long, issues from the mountains in a bold spring, which had a capacity on August 14, 1902, when measured, of 21 second-feet. The owner, W. J. Wilkinson, a settler of forty years' residence, states that during the summer the flow is larger than it is during the winter. The waters are used by two small irrigation systems, the Wilkinson and the Striegler. A small rock dam at the head deflects part of the waters into the two ditches of the Wilkinson system, from which 12 acres are irrigated on each side of the creek. Near the mouth of the creek O. Striegler, by means of a rock dam 8 feet high and about 50 feet in total length, that deflects the water into a ditch on the left side of the creek, irrigates 18 acres in corn, cotton, oats, melons, etc. It is well to remember that the capacity of this creek was exactly three-fourths of that of the Noyes ditch near the courthouse in Menardville on the same day.

Old Mission ditch.—The San Saba mission was established at what is now known as old Fort San Saba in 1734, and it was from this the river took its name. The Franciscan fathers who established the mission constructed a system of irrigation the remains of which can

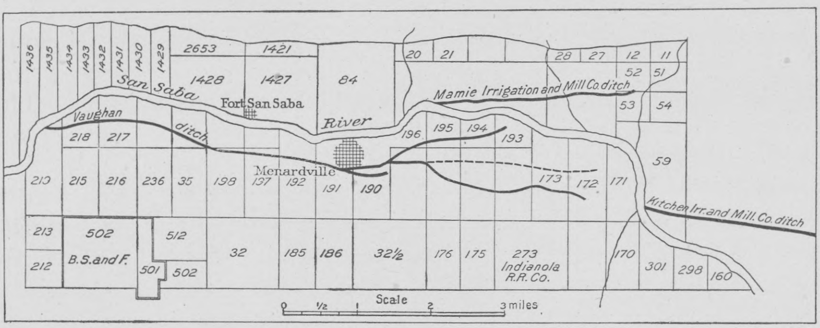


FIG. 10.—Map of Menardville irrigation systems.

be easily traced to-day. The dam was a short distance above the mission and the ditch was taken out on the south side of the river and skirted the hills one-half mile above Menardville.

There are three systems near Menardville—the Vaughan, the Sieker, and the Kitchen. (See fig. 10.)

Noyes ditch.—The Noyes ditch is nearly 10 miles long. The dam is built across San Saba River about 4 miles above Menardville, and the water returns to the river 5 miles below that town. The charter was obtained by the Vaughan Agricultural and Improvement Company in 1874, and the ditch was built soon after. It is claimed that this company put $12,000 into the work. This was an excessive cost, extra expense being incurred by the refusal of right of way in one instance, forcing the company to make a cut 16 feet deep and several hundred feet long. Further, the methods employed were rude and costly. Wheelbarrows were used to move the dirt, and in the cut the earth was thrown on staging and passed from man to man. There are 97 shares of stock, valued at $180 each. One year $1,200 was spent in improvements and another year $1,000, but the ditch pays all running expenses, cost of improvements, and 10 per cent on the shares at the foregoing valuation.

After construction the grade of the ditch was found to be irregular and unsuitable, so work has been done each year—cutting and filling—to reduce the slope above the Las Moras flume to a nearly uniform grade of 30 inches to the mile. At the flume there is a fall of 14 inches in 128 feet. At the point of the mountain, where the ditch curves with the hill and runs through rock, it is lessened in size and has a much steeper grade. The grade of 30 inches to the mile was established experimentally and satisfies as nearly as possible the necessity of avoiding silting on the one hand and erosion on the other. The ditch runs through coarse gravel part of the way, and there is a heavy loss from percolation. The straightening of the ditch, the reduction of the grade, and the tightening of the dam have given an available flow of water sufficient to irrigate 2,000 acres of land.

The dam is of rough limestone quarried at the spot, averaging, where seen on the front, 2 feet by 3 feet by 10 inches, and laid in courses without cement. The blocks are tied by bolts fastened to a log under the dam, passing up through the dam, and at the top are fastened by taps to cross-ties lying along the upper surface. The dam is slightly concave, and is about 200 feet long and 5½ feet high at the center of the front, with an irregular batter. It is 13½ feet wide on top at the center. It rests partly on rock and partly on gravel, and is backed with earth on a slope of nearly 2 to 1.

The water stands within a few inches of the top of the dam and overflows at every rise in the river. Judging from the high-water marks there are 10 or 12 feet of water passing over it at times. Below the dam is a pile of loose bowlders which holds the leakage through the dam and forms a water cushion to receive the fall. At every high rise the dirt is washed from the back of the dam, and when the water subsides it is at once replaced by dirt scraped from the north side of the river. The dam backs the water about 500 yards, the deepest hole being about 15 feet. The water is taken out on the south side, 100 or more yards above the dam, and is carried in a cut to the sluice gate a short distance below the dam.

A section of the ditch made a few hundred yards below the sluice gate gave the following dimensions: Top width, 15.2 feet; bottom width, 8 feet; depth, 2.7 feet; wetted perimeter, 16.5 feet; area, 29.83 square feet; maximum surface velocity, 2.17 feet per second, and mean velocity, 1.54 feet per second. The velocity was measured for 100 feet above and below the section, where there was not a very great difference in the dimensions of the ditch. The fall of the surface was found to be 0.1 foot in 195, or 1 foot in 1,950, or 2.7 feet in a mile. This, with a coefficient of $n=0.03$, would give a velocity of 1.57 feet per second, which is very near the observed velocity of flow, and gives a discharge of 46 cubic feet per second, or 2,300 inches, estimating 50 inches to 1 foot.

The flow of the main ditch was measured by current meter in August, 1902, at the bridge near the Methodist Church and it was found to be 28 second-feet. Two small ditches, one on the north side of Main street and the other skirting the foothills of the south, taken out above the bridge referred to, were carrying one-third and 1 second-foot, respectively.

As to the amount of water required to the acre, one man who irrigates 40 acres of land uses 40 inches of water and occasionally needs a little more. On another farm they use 15 inches of water on 12 acres of garden truck. On the upper part of the ditch above the town the water is measured and distributed by the inch; that is, if a man wants 20 inches of water the gate opening on his ditch is set for a 20-inch flow and remains in that position throughout the season. From the town down they use the water in rotation, because, owing to a mistake in laying out the distributaries, the use of water above interferes with the flow below. So they alternate every seven days, the residents above using all the water that reaches them during that period, the lower owner having all the water during the next seven days. One-half mile below the town the Waller lateral runs off to the left toward the river bend. At present (1902) it is the custom to let those on the Waller have the whole flow one week and those on the main ditch the next, etc.

Assuming the acreage irrigated to be 2,000 acres, we have from our calculated flow a little more than 1 inch to the acre, which is the allowance in actual use, and a duty of 44 acres per cubic foot per second of flow for the water entering the main ditch. These measurements were made at but one point, and can be considered only approximate for the whole ditch. For accuracy they should be repeated at a number of points and proper allowance be made for percolation and leakage. In general, the estimate is that three waterings of 4 inches will make a crop.

Sieker system.—One mile below Menardville is the dam of Capt. L. P. Sieker. It is of peculiar construction, as shown in fig. 11. In a line across the river piles 6 feet apart were driven into the bed of the river with a pile driver, being left 5 feet above the river bottom. Parallel to this row and 6 feet from it another row of piles was driven in such a way that the piles of the lower row were immediately below those of the upper row. The piles were thus located at the corners of 6-foot squares. The piles of the lower row projected only 3 feet above the bed of the river. Sheathing boards 2 inches thick were spiked on the upper side of the upper row of piles, while logs were laid against the upper side of the lower row of piles and were wired to them. The inclosure between the sheathing and the logs was filled with loose stone. This added weight and increased the stability already obtained by sinking the piles. To prevent leakage cedar tops were piled above the dam and were tramped into the soil and against the dam. On top of the cedar boughs earth was filled to within a short distance of the top. This method of constructing a dam has proved very successful. The dam is 380 feet long, 5 feet high, and 6 feet wide.

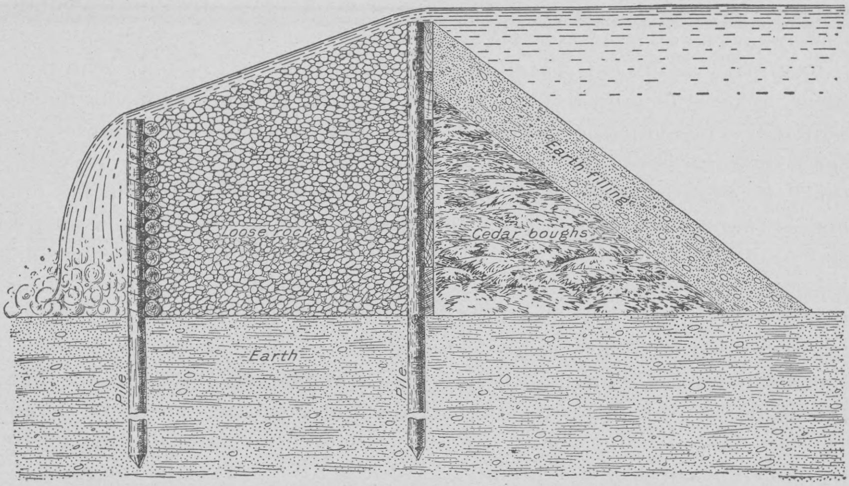


FIG. 11.—Cross section of Sieker's dam on San Saba River.

From the lake thus formed leads the ditch known as the Mamie ditch, built in 1894. It was chartered for a length of 4 miles, but only 1¾ miles have been constructed. It is 6 feet wide and 2 feet deep. At one place it is forced to within 30 feet of the river, on account of the foothills crowding up to the river bank. The cut at this place was 18 feet deep and the bottom of the ditch 9 feet above

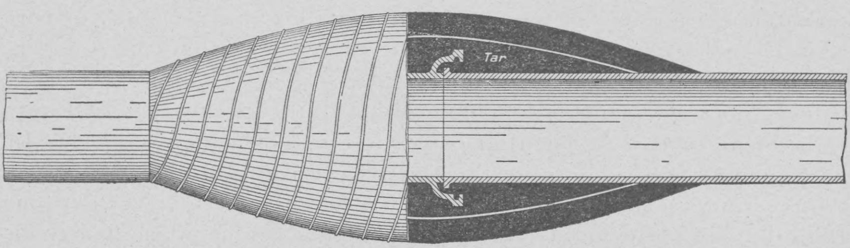


FIG. 12.—Flexible pipe joint used on the Mamie ditch.

the ordinary water level of the river. One hundred and seventy-five acres are irrigated from the ditch, but it has a capacity of 200 acres. The chief crops are cotton and corn. Cotton averages from 1½ to 2 bales and costs $1.25 a bale for transportation to the railroad. Corn brings from 15 to 20 cents more a bushel than at the markets on the railroad. Sweet potatoes average 250 bushels to the acre.

The ditch crosses four streams, Millers Branch, Temple Branch, Temple Field Creek, and Scalp Creek. At first the old form of wooden flume was used across these creeks and branches, the channels being 4 feet wide and 2 feet deep, but the excessive heat of summer caused constant leaks in the flumes, and they were finally abandoned as water carriers. The sides were taken off and the floors were left as supports for the pipe lines which were substituted to carry the water across the creeks. To counteract the expansion due to the heat a flexible joint, shown in fig. 12, was designed to connect the sections of the pipe. After the ends were brought together several inches of the pipe near the joint was heavily coated with North Carolina tar, heavy canvas was wrapped around the joint, the whole was again tarred, and the canvas was securely strapped to the pipes by wires twisted around the joint. A bulkhead was constructed across the ditch on each side of the creeks and the pipes were built into the bulkheads. At Millers Branch the flume pipe is 90 feet long, 18 inches in diameter, and has a fall of 14 inches; at Temple Branch the length of the pipe is 50 feet, its diameter 15 inches, and the fall 9 inches; the Temple Field flume pipe is 125 feet long and 12 inches in diameter, and the fall is 18 inches; at Scalp Creek the length of the pipe is 180 feet, its diameter 13 inches, and the fall 18 inches. All of these flexible joints and pipe flumes have proved eminently satisfactory.

Kitchen ditch.—This ditch is taken out $6\frac{1}{2}$ miles below Menardville and $5\frac{1}{2}$ miles below the Sieker or Mamie dam. The dam is of brush, rock, and dirt, about 75 feet long and 7 feet high. The ditch leading from the lake formed by the dam is $4\frac{1}{2}$ miles long, 6 feet wide, and 2 feet deep. Three hundred acres were irrigated from it in 1902.

Vanderstücken system.—Twelve miles east of Menardville, on San Saba River, is a pumping plant owned by Emile Vanderstücken, consisting of a 28-horsepower steam engine operating by a belt a Van Wie centrifugal pump having a capacity of 5,000 gallons a minute, or 11 second-feet, with a lift of 31 feet. The total cost of the plant was $1,500. No reservoir is used, the water being carried in a flume to the highest point on the land and distributed by ditches. The flume runs along a ridge for 150 feet and then branches.

Sloan system.—At Sloan, San Saba County, there is a series of perennial springs that gush forth from the foothills near San Saba River. Originally the water ran down to the low grounds and formed a pond, but about 1870 a ditch was constructed along the foothills to the river, which took the water away from the pond, and it soon dried up. A stone dam 200 feet long and 4 feet high was built to deflect the water into the ditch. The ditch shown in fig. 13 is 1 mile long, 5 feet wide, and 1 foot deep. The former pond is now an irrigated farm, through which runs a long sag. To convey the water across this sag a rock race and a pine and cypress flume are used. The soil is a rich, black loam, slightly sandy. The crops raised are corn, cotton, ribbon cane, and sweet potatoes. The yield per acre is generally from 40 to 60 bushels of corn, from 1 to 2 bales of cotton, about 290 gallons of molasses, and from 150 to 300 bushels of potatoes. The ditch is owned by Mr. J. A. Sloan & Sons, and in 1902 it irrigated 186 acres.

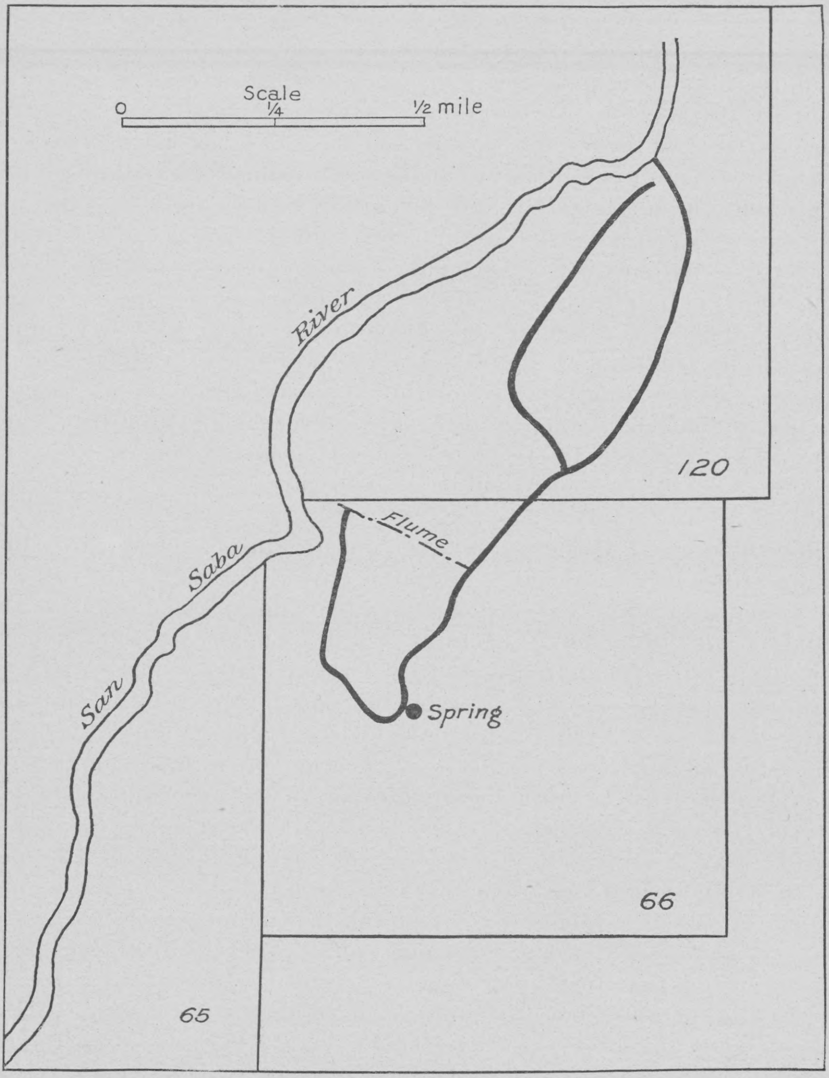


FIG. 13.—Map of Sloan irrigation system.

Doran system.—Seventeen miles west of the town of San Saba is the irrigation plant of W. R. Doran. The water is drawn from the river through a ditch 600 feet long into a pond from which it is pumped into the flume. A 16-horsepower engine runs a centrifugal pump against a lift of 28 feet, delivering 2 cubic feet per second. One hundred acres (in cotton, millet, cane, and corn) are to be irrigated.

West & Burnet system.—Ten miles northwest of San Saba West & Burnet have constructed an impounding reservoir of an estimated capacity of 20,000,000 gallons, by making a dam across a drainway. The dam is 705 feet long, 14 feet high, and cost nearly $1,000. The ordinary crops will be irrigated and the number of acres the canal will serve will be determined by trial.

King system.—Probably the oldest irrigation plant in the San Saba country is that of the King Sisters (Larkin King, manager), just above Sloan, on the south side of the river. There are two springs, known as the Fleming Springs, that issue from the foothills of the mountains and supply the King farm with sufficient water to irrigate 40 acres.

Ellis system.—Twelve miles above San Saba, on the south side of the river, Robert Ellis operates a pump irrigation plant, which was first erected late in the season of 1902. A stationary tubular 25-horsepower boiler furnishes steam to a 20-horsepower engine, which drives a 6-inch Rumsey pump against a lift of 25 feet. The water is pumped out of a walled-in well 6 feet in diameter and 19 feet deep from top of curbing, the well being supplied from the San Saba River by a 15-inch wooden pipe, constructed of leveled 2 by 4 pine lumber. The water is pumped into a canal that conveys it to the fields one-fourth mile from the pump. Ordinary crops of corn, cotton, etc., are irrigated.

Hawkins system.—Eight miles above San Saba, on the farm of Mrs. M. E. Cook, Thomas Hawkins has equipped a pumping plant by a 12-horsepower charter gasoline engine, which runs a 4-inch vertical Van Wie centrifugal pump against a lift of 33 feet. The plant cost $825, and with it, by the use of $4 worth of oil, 6 acres can be irrigated by the furrow system each day. By this plant 40 to 50 acres can be irrigated each season.

Proposed canal system.—Many surveys have been made with the view of putting in an irrigation system on a large scale in the San Saba Valley. Seventeen miles above the town of San Saba, at the Narrows, the river issues from the canyons which it has traversed for a distance of 60 miles, from a point about 12 miles below Menardville. From the Narrows to the junction of the San Saba and Colorado a fertile valley on each side of the San Saba River could easily be brought under irrigation. The flow of the San Saba at the Narrows, as determined by two measurements in June, 1902, by the writer, at a time when no rain of importance had fallen in its watershed for two years previous, was found to be 24.5 second-feet. To irrigate the 42,000 acres in the valley below, a system of storage reservoirs could easily be constructed by putting in dams across the river at the Narrows and near the mouth of Brady Creek. The deflecting dam at the Narrows would be about 550 feet long and 60 feet high to fill the north valley canal, which would bring under ditch all of the north valley between Doran's ranch and the Colorado. Two distinct surveys have been made by independent parties with the view of putting in a complete irrigation system in this valley. The soil is rich, and the possibility of irrigating the lands in the valley by storing up the flood waters in the deep canyons offers easy construction for the prospectors. Between the deflecting dam and Menardville there would be no adverse interest to complicate the situation, as there are no farming lands in this section of the river to be covered.

Systems east of San Saba.—Just east of San Saba there is a large tract of land extending from the mill creek that skirts the town to the foothills 3 miles east. This land could be irrigated easily, and offers an inviting field. From the lake formed by the dam across the creek a stone race leads out into a ditch that commands several hundred acres. The ditch is 2 miles long and is well built, as is shown by the substantial flume about one-fourth of a mile from the dam, which was used to carry the water across a sag. This ditch has not been utilized for two or three years, but it is reported that it will be brought into use again for the season of 1902. Near the foothills east of San Saba an effective spring, known as the Barnet Spring, furnishes sufficient water to irrigate the lands of Hambert Brothers and those of Mrs. Farrar. The ditch is a small surface trench, and could be rendered much more effective by repairs.

Maxwell system.—Twelve miles southeast of San Saba, on Rough Creek, Z. T. Maxwell has an irrigated farm of 40 acres, the water for which is supplied by perennial springs on the mountains. The water is conveyed from the springs by a ditch 1,500 feet long, which is tapped by three side ditches. The main ditch has a fall of 1 foot in every 300, while the side ditches have a fall of 1 foot in every 600. The soil is partly black loam and partly chalky and sandy. The farm has been in operation since 1880, and is one of the most successful in Texas. The crop in 1901 was distributed as follows: Twenty-one acres of onions, 2 acres of cabbages, 2 acres of tomatoes, 10 acres of millet, 5 acres of cane, and the remainder in corn, wheat, etc. A second crop is raised on the small-grain and the onion land. In 1901 the onion land yielded 180 bushels to the acre and a second crop of 50 bushels of peas to the acre.

Baker system.—Near Sloan post-office, on Richland Creek, a tributary of San Saba River, about 30 miles northwest of the town of San Saba, George Baker has a system of ditches from which he irrigates 150 acres, the principal crop being cotton. The water is taken from the Richland Spring by a cement and stone dam 25 feet long and 5 feet high. There are 2 miles of ditches on both sides of the creek, the width and depth of which are 4 feet and 2 feet, respectively. The plant was inaugurated in 1870, and the yield from the black and waxy valleys on each side of the creek is from $1\frac{1}{2}$ to 2 bales of cotton to the acre.

UPPER NUECES.

There are several small irrigation plants in Edwards and Uvalde counties, on the prongs of Nueces and Frio rivers, in the vicinity of Leakey, Barksdale, Vance, Riofrio, Montell, and Laguna. The following persons have irrigation plants: Tom Woods and M. Clymer, near Rock Springs; W. B. Patterson and H. Elms, near Leakey; W. D. Hutcheson, O. A. V. Burr, John Nelson, M. Red, J. W. Sparks, W. F. Woodward, S. W. McLaughlin, Mrs. W. A. Connell, W. A. Shockley, J. K. Lippard, B. F. Casey, J. H. Woods, and E. M. Jones, near Barksdale; Z. H. Pannell and A. R. Barker, near Vance; W. T. Patterson, near Riofrio; J. H. Etheridge, at Montell, and William Landrum, at Laguna.

Woods system.—The Tom Woods plant is a small one on the Pulliam Prong of Nueces River. It was built in 1883. The dam, which is 150 feet long and 1½ feet high, deflects the water into the ditch. It is made of logs, rock, and dirt. The ditch is 600 yards long, 2½ feet wide, and 1 foot deep. The soil is black alluvial along the banks of the stream, and 8 acres are irrigated and planted in corn, potatoes, cane, and Johnson grass. The yields per acre are as follows: Thirty-three bushels of corn, 200 bushels of potatoes, 2 tons of cane, and from 3 to 4 tons of Johnson grass. About 1 acre is sublet to another party for a garden.

Clymer system.—The plant of M. Clymer was constructed in 1897, and consists of a ditch 1,300 feet long, 2 feet wide, and about 1 foot deep. It takes its water direct, without the aid of a dam, from Hackberry Creek, a tributary of the East Prong of Nueces River. The soil is a black loam, 4 acres of which are irrigated for garden truck.

Hutcheson system.—W. D. Hutcheson, near Barksdale, has two ditches, both of which take their water from the South Prong of Campswood Creek, a tributary of Nueces River. The first ditch was taken out in 1889, on the east side of the creek. It is 500 yards long, 2 feet wide, and about 1 foot deep. It takes its water from the creek without the aid of a dam. The second ditch was built in 1893, on the west side of the creek. It is 400 yards long and of the same general dimensions as the first ditch. The water is deflected into it by a rock-and-earth dam 20 feet long and 3 feet high. The first ditch irrigates 7 acres and the latter 13 acres. The soil is a rich, black loam, and readily produces 40 bushels of corn or 1 bale of cotton to the acre.

Nelson system.—John Nelson's plant was inaugurated about ten years ago. It is near the post-office of Barksdale, on the South Prong of Campswood Creek. The dam is of logs, stones, and earth, is 30 feet long and 4 feet high, and deflects the water into the ditch. The latter is taken out on the left bank, is 600 yards long, 25 feet wide, and about 1 foot deep, and irrigates 150 acres in corn, potatoes, and cane, yielding 40 bushels of corn, 280 bushels of potatoes, and 5 tons of cane to the acre.

Red system.—The ditch of M. Red is on the South Prong of Campswood Creek, near the Barksdale post-office. It is 625 yards long, 2½ feet wide, and of an average depth of 1 foot. It was constructed in 1890, and takes the water from the stream by means of a log, stone, and dirt dam 18 feet long and 2½ feet high. Twenty-three acres of black, porous limestone soil, in corn, potatoes, cane, and vegetables, are irrigated. The yield per acre is 40 bushels of corn, 225 bushels of sweet potatoes, and 5 tons of cane.

Sparks system.—The ditch of J. W. Sparks is taken out just below that of M. Red, but on the opposite side of the creek. It is 2,100 feet long, 2 feet wide, and 1 foot deep, and irrigates 22 acres. The dam is made of logs, stone, and dirt; is 20 feet long and 2 feet high. The soil is black, and produces 1 bale of cotton, 40 bushels of corn, and 280 bushels of sweet potatoes to the acre.

Woodward system.—The system of W. F. Woodward, which is just below that of Mr. Sparks, on Campswood Creek, was constructed in 1895, and irrigates 25 acres of black, loose limestone soil in the usual crops of this section (corn, potatoes, and sorghum), the yield per acre being 40 bushels of corn, 300 bushels of potatoes, and 5 tons of sorghum hay. The dam is 24 feet long and 2 feet high, and deflects the water into a ditch 2,100 feet long, 2½ feet wide, and 1 foot deep. It is taken out of the left bank, but crosses to the right bank.

McLaughlin system.—S. W. McLaughlin's ditch is just northwest of that of W. F. Woodward, and takes its water from the left bank of Campswood Creek, by a dam of logs, stone, and dirt 40 feet long and 3 feet high. The ditch is 1,950 feet long, 2½ feet wide, and 1 foot deep. The soil is similar to that of the preceding plants, 14 acres of which are irrigated in the three chief crops of the Barksdale section—corn, sweet potatoes, and sorghum.

Connell system.—On the farm of Mrs. W. A. Connell there occurs one of the springs (Connell Spring) that really are the source of the water of the upper sections of Nueces and Frio rivers. Its waters are led off into a ditch 800 feet long, 2½ feet wide, and 1 foot deep, which irrigates 24 acres, in corn and potatoes. The spring is near a stream, and the ditch runs parallel to the stream for about half its length and then crosses by a flume to the right bank.

Shockley system.—The next ditch below that of Mrs. Connell, on the short spring branch that is tributary to the East Nueces, is that of W. A. Shockley. The water is taken from the branch by means of a dam of logs, stone, and dirt 20 feet long and 2 feet high. The ditch is 2,700 feet long, 3 feet wide, and 1 foot deep. The system was constructed in 1894, and 50 acres are irrigated, the yield being 35 bushels of corn, 275 bushels of potatoes, and 5 tons of cane to the acre. Messrs. Woodward and Cunningham are joint owners with Mr. Shockley.

Lippard system.—The plant of J. K. Lippard, at Barksdale post-office, was erected in 1892, and consists of a stone-and-dirt dam 15 feet long and 1 foot high across Campswood Creek and a ditch 1,500 feet long, 2 feet wide, and 1 foot deep. This plant irrigates 12 acres of the black, porous limestone soil planted in corn, sweet potatoes, and sorghum, producing 35 bushels of corn, 275 bushels of potatoes, and 5 tons of cane to the acre. The ditch is taken out of the left bank of the stream, but crosses the creek by a flume, thus irrigating land on both sides.

Casey, Taylor, and Graham system.—B. F. Casey, M. M. Taylor, and Oscar Graham (Barksdale) are the joint owners of a ditch that was constructed in 1898 to take water from a short spring branch tributary to the East Nueces. The ditch is 1½ miles long, 4 feet wide, and 2 feet deep, and irrigates 40 acres, the yield per acre being 40 bushels of corn and 1 bale of cotton. The dam is of logs and dirt, 40 feet long and 3 feet high.

Burr and Woods systems.—On the Pulliam Prong of the Nueces O. A. V. Burr and J. H. Woods each took out a ditch in 1899. That of the former is a half mile long, 2 feet wide, and 2 feet deep, and irrigates 50 acres of black bottom land, which yields 30 bushels of corn, 1 bale of cotton, 5 tons of cane, and 280 bushels of sweet potatoes to the acre. The dam is of rock, 150 feet long and 6 feet high. About one-fourth mile below the Burr dam is the dam of Mr. Woods. It is of logs, dirt, and brush, 50 feet long and 2 feet high. The 12 acres irrigated produce the usual yield of corn, cane, and potatoes.

Jones systems.—E. M. Jones, at Barksdale, built two small ditches in 1893. The upper is 600 feet long, 2 feet wide, and 1 foot deep, and irrigates 2 acres. The brush-and-dirt dam is 10 feet long and 3 feet high. The lower ditch is of the same length and dimensions and irrigates the same amount of land as the upper ditch.

Elms system.—The system of H. Elms is near Leakey, on the Rio Frio. It was constructed in 1894, and consists of a ditch on the east side of the river 1½ miles long, 4 feet wide, and 2 feet deep. The dam is of dirt and stone, 40 feet long and 1 foot high. Forty acres of corn, cotton, and sorghum are irrigated, yielding the usual quantities for this section.

Patterson systems.—About 4 miles northeast of Leakey W. B. Patterson has a brush-and-stone dam across the Rio Frio 45 feet long and 2 feet high, built in 1896. This supplies a ditch 2 miles long, with a top width of 5 feet, a bottom width of 3 feet, and a depth of 3 feet. It was first used in 1897, and commands 300 acres, 125 of which have been cultivated. Near Riofrio, just across the line in Bandera County, is the Patterson ditch, owned by a company composed of three men. It was constructed in 1868, is 2 miles long, 5 feet wide, and of a depth varying from 3 to 4 feet. The dam is of brush and gravel, 30 feet long and 4 feet high. The soil is black and sandy, and under irrigation is very productive. In 1901 about 700 acres of cotton, corn, oats, and garden truck were irrigated. The yields per acre were 1 bale of cotton, 45 bushels of corn, 20 bushels of wheat, and 75 bushels of oats.

Etheridge system.—At Montell, on the Upper Nueces, Mr. J. H. Etheridge is the owner and operator of the Casa Blanca Irrigation and Mill ditch, which was constructed in 1894; it is 2½ miles long, 6 feet wide, 7 feet deep for the first half mile, and from 2 to 3 feet deep for the next 2 miles. Water is taken from Nueces River by a dam of loose rock, which raises the water to the ditch. The dam is 300 feet long and from 2 to 3 feet high. The soil irrigated is rich alluvial, and corn yields 40 bushels and cotton three-fourths of a bale to the acre. During the season of 1901 this ditch irrigated 100 acres.

Landrum system.—The plant of William Landrum is near Laguna. The source of supply is five large springs, which have been forced into one by means of dams. The dams range in length from 30 to 100 feet and in height up to 6 feet. Some of them are of rock, others of clay. The water of the springs is forced into a ditch three-fourths of a mile long, 4 feet wide, and 2 feet deep, and is capable of irrigating more than 100 acres, although only 30 acres are usually irrigated. The system was constructed in 1894 and 1895.

KERR COUNTY.

In Kerr County, on the headwaters of Guadalupe River, there are a few small plants. That of Robert Tedford, near the post-office of Japonica, takes its water from Honey Creek by means of a loose-stone dam 15 feet long and 2 feet high. The ditch is 900 feet long, 1½ feet wide, and about 1 foot in depth, and irrigates 4 acres of tomatoes, onions, sweet potatoes, etc.

The plant of Silas Welch, near the post-office of Mountain Home, takes its water from a spring by means of a rock dam 40 feet long and 2½ feet high. The ditch, constructed in 1901, is 6,000 feet long, 3 feet wide, and about 1 foot deep, irrigating 8 acres of corn and garden truck.

Kaiser system.—W. C. Kaiser early in 1902 installed a pump plant a mile below Mountain Home, on the left bank of Johnson Fork. A 16-horsepower gasoline engine operating a centrifugal pump against a lift of 25 feet irrigates about 50 acres in the ordinary crops. This plant paid for itself in one season.

Thrailkill system.—W. F. Thrailkill, just below Mountain Home, irrigates 10 acres from Smith Branch, a tributary of Johnson Fork of the Guadalupe. A small plank dam 1 foot high deflects the water into the ditch.

KIMBLE AND EDWARDS COUNTIES.

Irrigation in Kimble County is chiefly confined to the valleys of the creeks tributary to Llano River and its two branches, the North Llano and the South Llano. This is due to the great violence of the river during high stages and the consequent difficulty of building dams and maintaining ditches. Capt. C. K. Gordon's is the only plant that takes its water direct from the river. There are no "company" ditches in the county; in some instances two or three men have formed partnerships, but all the plants are small. Few of them water more than 20 or 25 acres, while the average number of acres watered is much smaller. There are thousands of acres lying along the river and its larger tributaries that might be irrigated if sufficient capital were employed to successfully dam the river and use the water on a large scale.

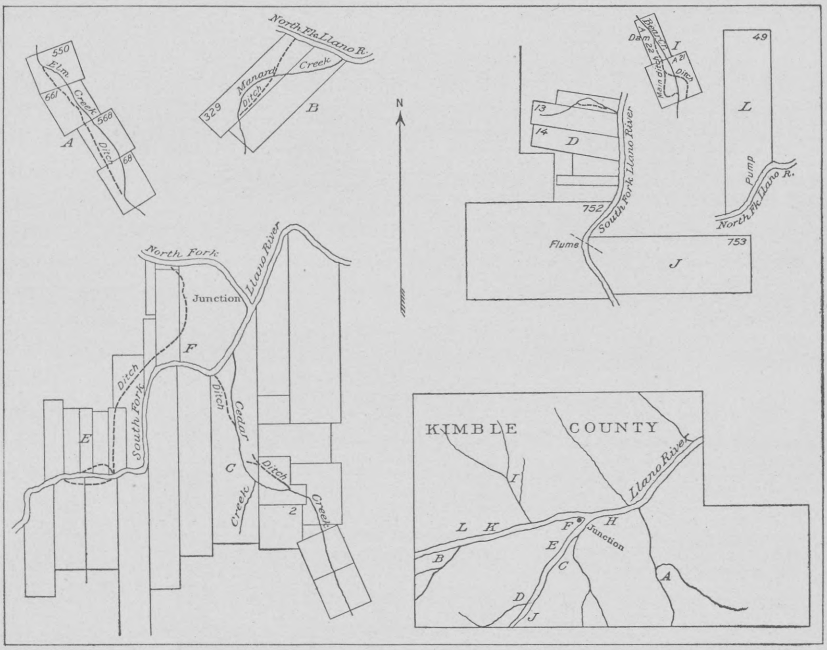


FIG. 14.—Map of Kimble County irrigation systems.

The following brief descriptions of the plants in Kimble County (see fig. 14) begin at the eastern end of the county and proceed westward. The plants are described in order downstream.

JOHNSON FORK OF LLANO RIVER.

The first stream on which there are irrigation plants is the Johnson Fork of the Llano, which joins the river about 5 miles below Junction City. There are four plants on this stream, as follows:

Moos system.—W. G. Moos's plant is three-fourths of a mile from the mouth of the Joy Branch, a small tributary of the Johnson Fork, about 11 miles above its mouth. It takes the water from the right bank of the Joy Branch, by means of an earth-stone-timber dam 60 feet long and 3 feet high. Thence the water is conducted along the right bank about 200 yards, and then is flumed to the left bank. The ditch is a fourth of a mile long, 1 foot deep, and flows at an average depth of 1 foot. Eighteen acres are irrigated. The principal crop is corn, which produces about 30 bushels to the acre. Oats, wheat, cane, sweet potatoes, alfalfa, and garden vegetables are also grown. The yield of oats is about 40 bushels to the acre, and of wheat about 20 bushels. The cost of the dam was $25, of the ditch $25. The dam was first built by John Joy, prior to 1879.

Rembold system.—P. J. Rembold's plant is a little more than a half mile below the one just described, and is also on the Joy Branch. It was built by John Joy, prior to 1879. The dam is 60 feet long, of rock and gravel, and raises the water about 1 foot. The ditch is 300 yards long, 3 feet wide, and flows at a depth of 18 inches. Last year (1901) Mr. Rembold irrigated only 3 or 4 acres, but there are 67 acres of cultivated land within reach of the ditch. As many as 20 acres have been irrigated within recent years. Besides a garden the crop consists solely of Johnson grass. The cost of the dam was about $10, of the ditch $75.

Long system.—A. B. Long's plant is about 4 miles farther down the Johnson Fork. The water is raised 3½ feet by means of a 75-foot timber dam, consisting of upright timbers held in place by cedar posts and filled above with stones, gravel, and earth. Power is obtained by means of an undershot water wheel 8 feet in diameter and 5 feet long, operating two 6-inch force pumps of the walking-beam pattern, which raise the water 40 feet, through 100 feet of 5-inch iron pipe, to a flume. The flume conveys the water 100 feet, to a ditch 1½ feet wide, which carries it 600 feet farther, or to the field. Only 5 acres are irrigated, and only vegetables and fruits will be grown. It is interesting to note that an experiment is being made with strawberries. The cost of the dam was $50, of the flume and ditch $54, of the pipe $100, of the pumps $36, of the wheel $100, making a total of $340. The plant was constructed about 1898. This plant was recently sold to J. B. Bullard.

Owens system.—Eight miles from Junction City W. J. Owens operates a small pump plant, on the left bank of Johnson Fork of the Llano. A 12-horsepower steam engine operates a 3½-inch centrifugal pump against a small lift and irrigates a garden. This could easily be made to bring 200 acres under irrigation.

Armstrong system.—G. R. Armstrong's plant is on the Johnson Fork, about 3½ miles above its mouth. By means of a dam 86 feet long the water is raised 5½ feet. A race 86 chains long conducts it to a 15½-inch turbine, which operates a No. 4 submerged centrifugal pump. The pump raises the water 20 feet, at the rate of 600 gallons a minute (1⅓ second-feet). A reservoir 4½ feet deep, scraped out of the earth, and covering 1 acre, receives the water and distributes it to the field through a ditch a half mile long. Sixty-five acres of black loam are irrigated. The crop consists solely of alfalfa, which is grown for home use. The cost of the entire plant was $1,200.

CEDAR CREEK.

Cedar Creek, which flows into the South Llano about 1 mile southwest of Junction City, furnishes water for four plants, as follows:

Allen & Kelley systems.—J. A. Allen and W. H. Kelley own the first plant in partnership. It was constructed by J. H. Clements, and was completed in 1897. The ditch is three-fourths of a mile long, about 3 feet wide, and the water flows at an average depth of 10 inches. It takes water from one of the head springs of Cedar Creek, by means of a very simple dam of earth, logs, and stone. The dam is about 18 feet long and 2½ or 3 feet high. Immediately on leaving the dam the water is flumed across Cedar Creek, to the right bank, and soon branches. One of the branches is flumed across the creek, and after watering a small field is allowed to return to the creek. The other branch, at the point of separation, is flumed across a small draw, and after watering several small fields empties into the main ditch. Twenty acres of black soil are irrigated, usually planted in corn, oats, wheat, and cane. The yield of corn is about 40 bushels to the acre, of oats 60 bushels, and of wheat 23 bushels. The dam is about 5 miles above Junction City.

J. A. Allen and E. F. Kelley own the next plant, which is about a half mile below the one just described. This was the first dam built on the creek, being constructed about 1892. It is 60 feet long and is made of stone to a height of 4 feet. The ditch is three-fourths of a mile long and 3 feet wide, and carries a stream about 10 inches deep. The water is taken from the right bank of the creek about a half mile below the plant just described, waters a small field, is flumed across the creek and waters a second field, is again flumed to the right bank, and after watering a few acres is once more carried to the left bank and the remaining water is distributed through the largest of the fields belonging to the system. The large amount of fluming in this and the J. A. Allen and W. H. Kelley plant is made necessary by the sharp bends of the creek and by the precipitous bluffs. Thirty-three acres are irrigated, 8 acres belonging to Mr. Allen and 25 acres to Mr. Kelley. Corn and wheat are the chief crops.

Jarvis & Hodges system.—R. L. Jarvis and G. W. Hodges own the next plant, which is about 1½ miles downstream. The dam, which has just been replaced, consists of walnut-log pens securely bolted together and filled with stones. There are seven sections 10 feet long and two sections 8 feet long, all 6 feet wide. The upstream side is filled with gravel. The dam is 86 feet long and 4 feet high. The ditch is 80 chains long, 3 feet wide, and carries 6 inches of water. It emerges on the right bank of the stream and continues on that side. Forty-four acres are irrigated, 19 belonging to Jarvis, and lying nearest the dam, and 25 belonging to Hodges. The crops are corn, potatoes, wheat, and oats—chiefly corn, which yields about 40 bushels to the acre. The cost of the dam was $40; the expense of maintaining is about $40 a year.

Taylor system.—W. W. Taylor's plant is just above the mouth of Cedar Creek. The dam is 60 feet long and 3 feet high, built log-pen style, and filled with stones and earth. The ditch is 2 miles long, 2½ feet wide, and carries 8 inches of water. It is on the left bank of Cedar Creek. It divides about 600 yards after leaving the creek, and one branch is flumed 75 yards, to the right side, where it waters the smaller field. Seven acres are irrigated. The crops are chiefly corn and potatoes. A garden is also watered. The cost of the dam was $25; the cost of the ditch, $300. The plant was constructed by Z. I., J. B., and J. A. Williams, about 1896.

BAILEY CREEK.

Jenson system.—On Bailey Creek, which flows into the South Llano about 10 miles above Junction City, is W. J. Jenson's plant. There is no dam, the water being taken direct from a spring on the left bank of the creek and carried in a flume across the creek and for about 350 yards along the left bank, where it divides. One branch is carried to a field on the right bank and the other across the creek again, in a 3½-inch iron pipe, and waters a field on the left bank. Only 4 or 5 acres are irrigated. Cane, corn, sweet potatoes, and garden vegetables are grown. The flume carries about 40 gallons a minute (one-tenth of a second-foot). The total cost of the plant was $100.

KYAC (CAJAC) CREEK.

Kyac (or Cajac) Creek, which flows into the South Llano from the left side, is the next stream that is used for irrigation. Four systems take water from this creek, as follows:

Dupuy system.—Maj. R. T. Dupuy's plant is about 2 miles from the mouth of the creek. There is no dam. The water is taken from a spring on the left bank of the creek, is flumed to the right bank, and is then carried by a 3-inch pipe to the field about 500 yards below. Seven acres are irrigated. The crops are oats and cane; a garden is also watered. The cost of the ditch was $30. The plant was constructed about 1883.

Griffith system.—S. A. Griffith's plant is about a half mile below the Dupuy plant. A lumber dam 50 feet long raises the water 2 feet. The ditch is a half mile long, 2 feet wide, and carries water to a depth of 6 inches. The water is taken from the right bank of the creek, but is soon flumed to the left bank, where it waters two small fields of 12 and 4 acres, respectively. The crops are chiefly wheat, corn, and vegetables. It is interesting to note that ribbon cane is successfully grown on a small scale. A yield of 200 gallons was raised from half an acre. This crop sells at 50 cents a gallon. The cost of the dam was $25; the cost of the ditch $150. The plant was constructed by Q. Lowe in the eighties.

Bishop system.—J. L. Bishop's plant is a half mile below Griffith's. The dam is of stone, earth, and brush, 40 feet long and 18 inches high. The ditch is a half mile long, 2 feet wide, and carries a stream 6 inches in depth. The water is taken from the right bank of the creek. About 600 yards below the dam the ditch branches, one branch watering two fields near the point of separation, the other branch being flumed 106 feet across to the left bank, where it waters a third field. Fourteen acres of black loam are irrigated. The crops are sweet potatoes, corn, oats, millet, ribbon cane, and cotton. The noticeable feature about this plant is that 1½ acres were planted in cotton last year and one-fourth of an acre in ribbon cane, unusual crops in this county. The 1½ acres of cotton produced one bale; the yield of the cane was about the same as on Griffith's farm. The cost of the dam was $10; the cost of the ditch $150.

Calentine system.—F. L. Calentine's plant (on Mrs. Wooten's farm) is at the mouth of Kyac Creek. The dam, which is of logs, stone, and brush, is 80 feet long and 1½ feet high. The ditch is one-fourth of a mile long, 2½ feet wide, and carries a stream 5 inches deep. The water is taken from the right bank of the creek, is flumed 120 feet, to the left bank, and distributed to a field which lies along the South Llano. Twenty-five acres are irrigated, though 100 acres could with little trouble be put under the ditch. The chief crop is corn, 35 or 40 bushels of which were raised in 1900 on the irrigated land of this farm, while only 15 or 16 bushels were raised on the nonirrigated land. The cost of the dam was $5; the cost of the ditch $100. The system was constructed in the eighties.

FLEMMING BRANCH.

Flemming system.—O. B. Flemming's plant is on the Flemming Branch, a short distance above the confluence of that stream with the South Llano and about 15 miles above Junction City. His largest field lies along the Llano. The dam, which is of earth, logs, and stones, is 20 feet long and raises the water 1 foot. The ditch is a half mile long, 2 feet wide, and flows to an average depth of 6 inches. The water is taken from the right bank of the stream, is conveyed about 300 yards along the right bank, and then the ditch divides, one stream being flumed across to the left bank, where it waters a field of 5 acres, the other stream irrigating a field of 30 acres. The crops are corn, oats, cane, alfalfa, and a garden. The cost of the dam was trivial; the cost of the ditch was $75. The plant was constructed in 1890.

LITTLE PAINT CREEK.

Dougherty system.—The next plant in this vicinity is on what is known as the A. H. D. Dougherty place, at present (1902) occupied by G. F. Wood. An earth-and-stone dam 50 feet long raises the water 1 foot. The ditch is three-fourths of a mile long, 2 feet wide, and carries a flow 6 inches deep. The water is taken from the east bank of Little Paint Creek, which flows into the South Llano from the left bank, about $1\frac{1}{2}$ miles above its confluence with the South Llano. A large tank, constructed by throwing up embankments of earth, affords a storage reservoir 100 feet long, 20 feet wide, and $2\frac{1}{2}$ feet deep. Twenty-five acres are irrigated. The chief crop has been corn, which yields 50 bushels to the acre. Twenty acres of cotton are to be planted in 1901. The cost of the dam was small; the cost of the ditch was $150.

SOUTH LLANO RIVER.

Baldwin system.—J. A. Baldwin has two small plants on the left bank of the South Llano, about 13 miles above Junction City. One of these plants makes use of a spring and has no dam and no ditch. A one-half-acre garden is irrigated. The other plant has a dam 10 feet long across a small spring branch which raises the water 1 foot. There are 100 yards of ditch 1 foot deep. Two acres of cane and corn are irrigated. The cost of the dam and ditch was trifling.

Hunger system.—T. Hunger has a small plant on the Ford Hollow Spring, a short distance from the South Llano and about 13 miles from Junction City. The water is taken directly from the spring, and is conveyed 1,150 feet, in a flume, to the garden irrigated. The flow is about 15 gallons a minute. A 1-acre garden is irrigated, from which Mr. Hunger derives a profit of about $250 a year. The flume cost $75. The plant was constructed in 1896.

Taylor system.—T. C. Taylor's plant is 17 miles above Junction City on the South Llano, though it does not take its water from the river. It is the last plant in Kimble County on the South Llano. The dam, which is of stone, is 5 or 6 feet long and raises the water about 10 inches. The water is taken from the Christmas Spring, on the left bank of the South Llano, and is carried under the river to the right bank in an iron pipe 300 feet long, and thence to the ditch through 1,326 feet of 8-inch sewer pipe. The ditch distributes it immediately to two fields of 14 and 11 acres, respectively. The principal crops grown are corn and cane, which are used at home for feed. The corn yields 40 bushels an acre. The cost of the dam was trivial; the cost of the iron pipe, $225; the sewer pipe, $331. The plant was constructed about 1892. Until the spring of 1901 Mr. Taylor used a flume instead of the 8-inch sewer pipe.

Barrett & Stephenson system.—C. C. Barrett and W. M. Stephenson own a plant about $2\frac{1}{2}$ miles above Taylor's plant, just described, in Edwards County, about 2 miles across the Kimble County line. There is no dam, the water being taken directly from a number of beautiful springs which issue from the bluff on the left side of the South Llano. As a rule the bluff is too precipitous to permit the construction of a ditch, hence the water is carried in a flume a large portion of the distance to the field, a tract of 25 acres about 1 mile down the river. The principal crops are corn, wheat, and cane. The cost of the flume and ditch was $200. It was constructed about 1895. This farm has only recently been purchased by Messrs. Barrett and Stephenson, and is generally known as the Black Place. The present owners intend to construct a new plant this summer (1901). They purpose to build a 4-foot dam across the Llano and use an 8-foot by 10-foot water wheel for power. This will operate an elevator pump to raise the water. Twenty-eight acres will be irrigated.

Huffman system.—One mile above Barrett's, on the South Llano, in Edwards County, is the plant of M. Huffman. There is no dam. The water is taken from a spring on the left bank of the river. The ditch is 300 yards long, 2 feet wide, and carries a stream 1 foot in depth. Seven acres are irrigated. Corn is the sole crop. The yield is 40 or 50 bushels to the acre. The cost of the ditch was $75. It was constructed by Henry Baldwin about 1895.

BEAR CREEK.

There are several plants on Bear Creek, a tributary of the South Llano, as follows:

Hall system.—The first plant in order coming down East Bear Creek belongs to Fred S. Hall. It is about 13½ miles above Junction City. The water is raised 4 feet by means of a timber dam, consisting of upright timbers held in place by cedar posts and filled with earth on the upper side. Below the dam the water falls on a cushion of cedar logs arranged parallel to the course of the stream. The ditch is a half mile long and 3 feet wide. The water flows about 9 inches deep, and irrigates a field of sandy loam containing about 9 acres. Last year (1900) the following crops were raised: Alfalfa and oats, 3 acres; garden, 1 acre; orchard, 2 acres; bermuda grass, 1½ acres; sweet potatoes, 2 acres. The sweet potatoes yielded 300 bushels to the acre, and were sold on the spot at 50 cents a bushel. The plant is now being enlarged and will be finished in time to irrigate the 1901 crop. About 800 yards below the dam is a branch ditch, which will be carried across the creek by means of 475 feet of 10-inch drain pipe laid under the creek. This will enable him to irrigate a field of 20 acres on the left side of the creek. The cost of the dam was $150; of the old ditch, $100, and of piping and new ditch, $150. The plant was constructed in 1895.

Reid system.—J. H. Reid's plant is on West Bear Creek, about 16 miles above Junction City. The water is raised 18 inches by means of a common earth dam about 25 feet long. It is then carried, at a depth of 4 inches, through a ditch 12 inches wide and a half mile long to a small field of 8 acres (in two patches). The crops raised in 1900 were corn, 2½ acres; sorghum, 2½ acres; potatoes, onions, etc. The cost of the dam was probably not more than $5; of the ditch, about $50. The ditch is on the right bank of the stream.

D. L. Stewart system.—D. L. Stewart's dam is about 1 mile below Reid's. It was built in the eighties by John T. Mayes. It is 100 feet long and 3 feet high, and is made of earth and logs. The ditch is 1 mile long, 18 inches wide, and carries the water to a depth of 7 inches. The water is taken out of West Bear Creek, and is carried along the right bank for about 400 yards, when it is flumed across to the left bank. The field irrigated is mostly black loam, and contains 30 acres. The cost of the dam was $50; of the ditch, $150.

Morales system.—M. Morales's plant is on the left bank of West Bear Creek and is about 2 miles below that of D. L. Stewart. The dam is of stone and earth 150 feet long and 3 feet high. The ditch is about 2 feet wide and three-fourths of a mile long. This is one of the best as well as one of the most expensive ditches in Kimble County. Along part of its course it is walled with stone. Most of the remainder runs through a cut which averages about 5 feet in depth. The field irrigated contains 10 acres. The cost of the dam was $100; of the ditch, $175. The plant was constructed in 1899.

"L. C. pasture" system.—About a half mile below the Morales plant, and on the same stream, is the dam belonging to the "L. C. pasture," at present owned by G. D. Tarlton, of Hillsboro. It was constructed in the seventies, and is probably the oldest plant in the county. It is of earth, about 80 feet long and 2½ feet high. The ditch is 3 feet wide, a half mile long, and flows perhaps 800 gallons of water a minute (nearly 2 second-feet). It is carried along the left bank of the stream. The field of about 8 acres is used to raise alfalfa for the use of the ranch. A branch ditch also irrigates a small garden. The cost of the dam was about $30; of the ditch, about $40.

Alec. Stewart system.—Alec. Stewart's plant is just below the junction of East and West Bear creeks. It is 2 miles below F. S. Hall's and 1¼ miles below the "L. C. pasture" dam. The dam is similar to that of F. S. Hall, already described. It is 250 feet long and 3 feet high. The ditch is 1,000 yards long and 3 feet wide, and carries water to a depth of 12 inches. One hundred yards of the ditch is carried through a cut 4 feet deep. This is a new plant, having been constructed during the present spring (1901). The field irrigated, which contains 15 acres, is on the right bank of the creek. The cost of the dam was about $150; of the ditch, about $100.

Menge system.—William Menge's plant is on Walnut Creek, a tributary of West Bear Creek. It is about a half mile southwest of the dam of D. L. Stewart, and is a very small plant. The dam is 150 yards long and 12 inches wide, and flows about 50 gallons a minute. The field irrigated is a 1-acre truck patch.

Gordon system.—Capt. C. K. Gordon's plant is on the North Llano, 10 miles above Junction City. The water is lifted by means of a No.

7 centrifugal pump, operated by a 15-horsepower steam engine. The lift is 35 feet, 10 feet of which is by suction. Wood is used for fuel and costs practically nothing, as a quantity of driftwood is always on hand near the pump. The capacity of the pump with the present engine is 1,250 gallons a minute. There is no ditch. The water is discharged into a flume, by which it is carried 1,250 feet to the upper side of the field, crossing a road by means of an underground siphon. Between the road and the pump the flume is 20 inches by 12 inches, and is partially lined with zinc. Below the flume is 20 inches by 6 inches. No reservoir is used or needed. The plant is sufficiently large to irrigate 80 acres, but the field actually irrigated contains only 35 acres of black loam, with gravel subsoil. The crops raised are principally corn and alfalfa, which are used on the ranch. The average yield of corn is 50 bushels. The cost of the engine and pump was $800; of the house and appurtenances, $400; of the flume, $600; total cost, $1,800. The plant requires 1½ cords of driftwood to operate it one day. The wood is picked up near by. One engineer is required. A sawmill and a gristmill are also run by the engine.

Probable systems.—The flow of the South Llano at low ordinary stages is 90 second-feet near Junction City. A dam could be put in 10 miles above Junction City, and by bringing the ditch along the foot hills a mile west of the town and by taking it across the North Llano by a flume or inverted siphon 5,000 to 6,000 acres could be irrigated. In fact, the Ragsdale system did take out a ditch 4 miles above Junction City; but the dam was washed away some years ago, and it has never been rebuilt. It would also be possible to put in a system below the town by taking a ditch out on the north side of the main Llano. Any system put in will have to be very substantial, as the Llano is torrential at times.

SYSTEMS AT SAN ANTONIO AND VICINITY.

The irrigation ditches at San Antonio are historically the most interesting in the State, for here are found the oldest systems and structures, which have been in use more than a century. Additional interest is derived from the association of the ditches with the early missions and with the efforts of the Franciscan fathers to settle the Indians upon these lands and engage them in agriculture. These ditches traverse the city, often concealed by buildings and sidewalks.

MISSION AND NEIGHBORING DITCHES.

The original mission ditches, built by the Franciscan fathers between the years 1716 and 1744, are the Concepcion, the Alamo Madre, the San Jose, the San Juan, and the Espada, all dug to supply the lands belonging to the respective missions. In addition to these mission ditches, there was one, the San Pedro, which supplied water to the Villa Capital de la San Fernando, settled in 1730 by the immigrants from the Canary Islands, and one built much later than any of the others, under the superintendence of the governor, Baron Ripperda, for the supply of the citizens of the town, and called the Upper Labor ditch.

UPPER LABOR DITCH.

Beginning at the head of San Antonio River, the most recent of the Spanish ditches—the Upper Labor—is the first encountered. It was begun in 1776, under the general direction of the royal governor, and was ready for use in 1778, care having been taken that there should be no infringement of the prior rights of the five missions and the Canary Island settlers. The ditch took its water from one of the large springs at the head of the river by means of a loose rock dam. It follows the contour of the land on the west side of the river and ends in San Pedro Creek. It once commanded about 600 acres, but is now out of use. In 1877 the city replaced the old loose rock dam by one of masonry, and built an extension to the ditch, called the Alazan branch. The latter was abandoned in 1896, because residences were built on the land irrigated.

ALAMO MADRE DITCH.

The Alamo Madre ditch, built between 1718 and 1744 to supply water to the Alamo Mission and irrigate its lands, derived water from the river on the east side just opposite the Upper Labor ditch, by means of a low dam. The ditch follows the contour of the land and runs through the business part of the city. Its length is 6 miles. It irrigated about 900 acres, but is now closed.

SAN PEDRO DITCH.

San Pedro ditch was commenced in 1738 and furnished water to the Villa de la San Fernando, the parish church of which, now called San Fernando Cathedral, is the geographic center of San Antonio. The water for the ditch, taken from the pool in San Pedro Park, follows the east side of the creek and runs through the center of the city, irrigating 500 acres of land below the town. Its length is about 4 miles, and it is 2 feet deep and 6 feet wide. The management of the foregoing ditches long since passed out of the hands of the landowners and into those of the city authorities and is now intrusted to a ditch commissioner appointed by the mayor. The annual water rent is $2 an acre.

CONCEPCION DITCH.

The next ditch of importance is the Concepcion, built in 1729 and abandoned in 1869, after being in use one hundred and forty years. It was discarded on account of the dam, which was in the center of the city, causing much damage from overflow when there was a rise in the river. This ditch was constructed to furnish water to the Mission de la Concepcion and was the largest of the old ditches.

OLD STONE AQUEDUCT CARRYING THE ESPADA DITCH ACROSS PIEDRAS CREEK.

SAN JOSE DITCH.

The San Jose ditch was built about 1720 to supply water to and irrigate the lands of the mission of that name, 5 miles below the town. The water was taken from the west side of San Antonio River, about 2 miles above the mission, and was returned to the river about 1 mile below. This ditch was abandoned about 1860.

SAN JUAN DITCH.

The San Juan ditch taps the river on the east side opposite the Mission San Jose. It follows the contour of the land and carries water down to the San Juan Mission. It was built in 1731 and is still in use. It irrigates more than 450 acres of land.

ESPADA DITCH.

The Espada is the lowest ditch taken from San Antonio River, though one of the oldest. The Spanish Government constructed it in 1824 and settled families on the land covered, assigning to each about 12 acres, known as suertes (swerties) and supposed to be the amount of land that could be irrigated from the ditch in one day. The ditch takes its water from the west side of the river, 6 miles below the city, by means of a loose rock-and-brush dam 270 feet long, built on a natural ledge of rock extending across the river, making the total height of the obstruction 8 feet. The dam consists of layers of brush weighted by loose rock, with gravel and earth thrown in front, forming a very effective dam, the rock becoming gradually cemented together by a deposit of lime salts from the water. It crosses Piedras Creek on a stone aqueduct, shown in Pl. VI, which consists of a series of massive arches that seem in as good preservation to-day as when constructed, more than a century and a half ago.

This ditch fell into disuse about twenty years ago and was abandoned until 1895, when A. Y. Walton, jr., who owned several suertes of land, organized the owners of the lands commanded by it into a company (the Espada Ditch Company), cleaned out, widened, and deepened the old ditch, repaired the dam, and made some change in its course, the total cost being about $3,000. The ditch is now 3 miles long, has a bottom width of 5 feet, and carries 10 second-feet of water. It commands 400 acres, nearly all of which is irrigated. The annual cost of keeping the ditch in good working order amounts to 25 cents an acre, the work being done by the members of the company. The manager notifies the members when work is to be done on the ditch, and no trouble has been encountered in repairing it on this labor-assessment principle. The general manager keeps a complete record of the hours and dates upon which each irrigator is to have water. Each member gets water every fifteen days, and is allowed all he wants, but he must use it only during the hours assigned to him.

The appearance of the crops under these ditches, even in a time of so abundant rainfall as the first half of 1897, is a remarkable proof of the value of irrigation. The land is mostly an alluvial valley soil, very productive when watered. On irrigated fields the customary yield is at least a bale of cotton to the acre, while for the last five years the average on unirrigated fields has been hardly more than one-fourth that amount. Truck farmers raise all kinds of vegetables from early spring until frost in the greatest profusion.

TRUEHART DITCH.

Three-fourths of a mile above the head of the dam which supplies the Espada ditch is the head gate of the Truehart ditch, which is now out of use.

ARTESIAN WELLS.

There is some irrigation from artesian wells practiced in and near San Antonio. Following are brief descriptions of the plants:

Kampman system.—The most extensive plant is that of Mrs. Caroline Kampman, who has three wells on her ranch, 3 miles east of the city limits. One of these wells has a flow of 1,500,000 gallons in twenty-four hours, under 20 pounds pressure, or 2.32 second-feet. It is 970 feet deep, and was drilled at a cost of $3,000. It is allowed to flow on 200 acres of the owner's land, most of which is in Johnson grass and sugar cane and needs only a small portion of the water. By a system of ditches or storage tanks this well would irrigate 1,000 acres of land. Almost all of the water from the other two wells is wasted. All of the water is impregnated with sulphur. Mrs. Kampman owns another well near the head of the river, 2½ miles northeast of the court-house, from which 26 acres are irrigated, but it could easily irrigate 300 acres.

Collins system.—Three miles west of San Antonio River, lying along the International and Great Northern Railroad, F. F. Collins has a farm of 140 acres which is irrigated from an artesian well 600 feet deep and 12 inches in diameter. The flow of this well has been estimated at 700 gallons a minute (1.5 second-feet). The water is clear and pure. The tract owned by Mr. Collins consists of 140 acres, all of which can be irrigated from this well. The farm is divided into tracts of 12½ acres each. A three-room house and the 12½ acres adjoining rent for $250 a year for land, house, and water. The latter is conveyed to the land by 4,000 feet of 6-inch pipe and 4,000 feet of 4-inch pipe. This method of conveyance guarantees a minimum loss by leakage and affords a most effectual control. The well is provided with two outlets, one of which supplies the pipe line on the farm, the other connecting to the reservoir. The reservoir is a triangular piece of ground covering 1 acre, one side of which is parallel to the track of the International and Great Northern Railroad. The capacity of the reservoir is 4,000,000 gallons, and the well fills it in seventy-two hours. It will be used to conserve the water supply, and will enable all irrigation to be done in daylight. At night the flow will be shifted to the reservoir, and during the day water will be drawn from both the well and the reservoir.

Brady system.—The well of Thomas F. Brady is unique, in that it is deeper by several hundred feet than any wells in the vicinity. It is 6 inches in diameter and 1,450 feet deep. The water is soft and has the taste of rain water. It was noticed that the dry years affected it very slightly, but during the flush year of 1900 the water rose in the outflow conduit about one-fourth of an inch. Fifty acres of land are irrigated from the well, but it could easily irrigate as many more. Under present conditions the well is kept closed half of the time. The land is rented for $16 an acre, which includes the water rent.

Epp and Walters systems.—Just east of the Brady farm is the farm of John Epp, where a 4¼-inch well 884 feet deep irrigates 20 acres of forage, consisting mostly of cane and Johnson grass. Within a quarter of a mile of the Epp farm Mr. Albert Walters has a small well from which about 10 acres are irrigated.

Vandalle system.—About 2 miles west of the court-house, in the valley of Martinez Creek, Herman Vandalle has a 4-inch well 840 feet deep that irrigates 14 acres of garden truck. A small tank, 60 by 60 feet, has been constructed to conserve the flow and give a larger supply when necessary. The land rents for $25 an acre.

Koelblen system.—Near the Aransas Pass roundhouse Jacob Koelblen has a very successfully conducted irrigation plant from an artesian well. The well was bored in 1895. For the first 34 feet 10-inch piping was used. Into this was inserted an 8-inch pipe that extended to a depth of 200 feet, then 800 feet of 6-inch pipe was incased in this, and 1,027 feet of 4½-inch pipe completed the well to rock. The lower 70 feet was drilled into hard rock. A 4½-inch pipe leads from the well to a reservoir 72 feet by 30 feet, which borders on the east side of the San Pedro ditch, into which the waste water flows. The land irrigated lies on each side of the railroad track, the water being conveyed to it by pipes. Only 21 acres in garden are irrigated, but there is sufficient water to irrigate five times that amount. The water is rented out at $25 an acre. The drilling of the well cost $2 a foot, and the total cost of the plant, exclusive of land, was more than $4,000.

Dignowitty system.—A. F. Dignowitty owns two wells near San Antonio. The first well was bored in 1884, on the east side of Alazan Creek, 2½ miles northwest of the court-house. Water was struck at a depth of 160 feet, sulphur water at 210 feet. At 460 feet artesian water of 5 feet depth was struck, which shot 16 feet above the ground, giving a flow of 1,000,000 gallons per twenty-four hours. The water is clear and soft, of a temperature of 75° F., and is partly used for irrigation. The second well was bored in 1895. It is 1½ miles northeast of the court-house. At a depth of 20 feet a fine pottery clay 80 feet deep was encountered; at 435 feet iron pyrites was met; and at 445 feet a vein of fine liquid asphaltum, which rose 45 feet in the well. At 456 feet a fine petroleum oil was struck; at 490 feet a substratum of clear fresh water, which rose to within 46 feet of the surface of the ground; at 500 feet a strong current of natural gas; at 525 feet a hard sandstone; at 540 feet a very hard white sandstone; at 550 feet another stream of water that rose within 35 feet of the top. The well stopped at 659 feet in hard, white rock.

SEWAGE FARM.

The sewage of the city of San Antonio is conducted about 4 miles southwest of the city and there utilized for irrigating purposes. Early in 1897 R. W. Hamilton & Co. made a contract with the city whereby the firm, in consideration of an annual payment of $1,000 to the city, was to receive all the sewage and the use of a tract of 350 acres of land. The company had to grub the land, erect houses, construct ditches, etc., before they could realize any income from their outlay.

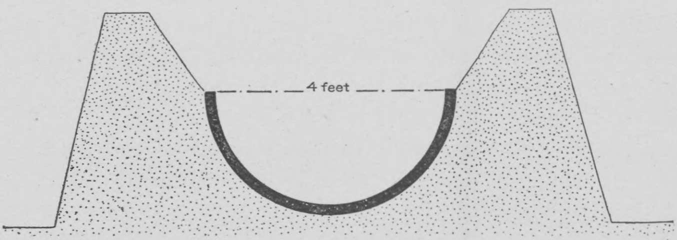


FIG. 15.—Cross section of sewer-farm ditch at San Antonio.

The sewage is delivered in the form of a half invert 44 inches in diameter, and to provide for an increased flow a dyke is constructed on each side of the invert, converting the whole into a canal the bottom of which is formed by the invert. (See fig. 15.) Three hundred and fifty acres are irrigated on what is known as the sewer farm proper, and the company has rented 150 acres from an adjoining farm, making in all 500 acres irrigated in 1901. In addition to this, about 3½ miles from the city the pipe line has been tapped and 50 acres are irrigated from the lateral. The flow is 10.8 second-feet, and 1,200 acres could readily be irrigated from it. At present the surplus is allowed to waste.

In September, 1901, the city leased the sewer farm and all of the sewage to R. H. Russel, J. A. Simmons, and others for a term of ninety-nine years. The lessees are to construct a ditch from the present outfall, a good and serviceable dam at Mitchells Lake, of a size sufficient to retain the surplus sewage of the city, and are to dispose of sewage by broad irrigation. They are also to guard the city against damages that may accrue from the sewage becoming a menace to private rights or a public nuisance. It is understood that the dam and ditch will cost about $20,000. The lessees are to have the sole use of the sewage, and are to receive all rents from Hamilton & Co. for the two years their contract has to run.

MISCELLANEOUS SYSTEMS.

Halff Brothers system.—At the crossing of the river on Mitchell street, San Antonio, Halff Brothers have installed a 10-horsepower gasoline engine, which operates a rotary pump. The lift from the river level to the pump is 6 feet, and the water is pumped through 6-inch pipes alternately on the east and west sides of the stream. The capacity of the pump is estimated at 167 gallons a minute (0.35 second-foot). During the season of 1901 it irrigated about 20 acres, but had to be run only about one-tenth of the time. The crops raised were the usual garden truck, which found a ready home market.

Groos system.—Four miles below San Antonio, on the east side of the river, F. Groos has a pumping plant run by water power. It is on an old race, and consists of one 35-inch Leffel turbine operating two rotary pumps having 5-inch discharge openings and an estimated capacity of 400 gallons a minute each. The head on the turbines is 5½ feet, and it is estimated that 40 horsepower is generated. This will require a flow of 80 cubic feet of water per second. The San Antonio River has been known to flow only 10 cubic feet per second, and if all of this were utilized on the turbine it would generate only 5½ horsepower. The flow on December 31, 1901, was only 41 second-feet at the "hot wells," and in July, 1902, it was only 9 second-feet.

Praeger system.—Otto Praeger's plant, just north of the "hot wells," consists of a 10-horsepower gasoline engine and a double-suction rotary pump having 4-inch discharge. The water is raised into a flume, from which it flows into a ditch 600 feet long. Sixty acres of Johnson grass are irrigated. After a crop is cut and taken off, the water is immediately turned on until the ground is thoroughly saturated. Four weeks later the ground is flooded a second time, and two weeks later the grass is cut. Thus a crop is cut every six weeks. It requires 100,000 gallons of water per acre for a single saturation, and the plant waters one-half acre per hour.

Layton system.—Four and one half miles south of San Antonio is the Layton irrigation plant, which consists of a 15-horsepower Springfield engine operating a 6-inch Gould centrifugal pump. The lift is 17 feet and the estimated capacity 1,000 gallons a minute. The water is pumped from San Antonio River, and to deliver the quantity stated under the lift of 17 feet requires, with an efficiency of 80 per cent, only 4½ horsepower. Sixty acres of vegetables for the local markets are irrigated.

Brown system.—Five miles south of San Antonio, on the east side of the river, B. H. Brown irrigated 35 acres by means of a 5-horsepower engine operating a 4-inch pump. The water is pumped from San

Antonio River against a lift of 20 feet. The plant cost $400. The soil is black and very productive. Sugar cane, vegetables, corn, and oats are the crops raised.

Mission Farm Company system.—This company uses the natural outfall of the sewer and irrigates 50 acres of sorghum, Johnson grass, oats, and fruit trees.

Camille system.—The Camille plant, 4½ miles from San Antonio, pumps its water from the sewer outfall. The lift is 23 feet, and the pump has a discharge pipe of 4 inches diameter and a capacity of 900 gallons a minute. The soil is black. Eighty acres of vegetables are irrigated.

Meerscheidt system.—Near Prospect Hill, Meerscheidt Brothers irrigate 50 acres from a 12-inch artesian well. The water in the well rises to within 7 feet of the ground surface and is pumped into the ditches by means of a 12-horsepower Springfield engine and a 5-inch centrifugal pump. The capacity of the well is 750 minute-gallons, and this is sufficient to irrigate double the present acreage in dry seasons.

Pickett system.—Thirty miles below, on the same river, near Floresville, in Wilson County, is the plant of A. G. Pickett. It was set up in 1893, and consists of a 40-horsepower steam boiler operating a Blake duplex steam pump, which is connected to the boiler by a 2-inch steam pipe. From 12 to 15 horsepower is used at present, it being the intention of the owner to extend the plant, by the addition of more pumps, as more land is brought under irrigation. The average distance from the water to the pump is 15 feet and the average lift 50 feet. There is no reservoir, the water being pumped directly into the ditch. The total cost of the plant is estimated at $2,500, and it requires one man, at a cost of 12½ cents an hour, to operate it. The pump is covered by high water in the river from two to four times a year. This plant was built to irrigate from 300 to 400 acres, and has sufficient boiler capacity for that acreage, but will require additional pumps. The present pump has a 7-inch suction pipe and a 6-inch discharge, and is estimated to pump about 750 gallons a minute, or 1.67 second-feet, sufficient to irrigate from 75 to 100 acres, but only 50 acres of fruits were irrigated in 1901. The annual cost of water is estimated at from $2 to $6 an acre, according to the amount of rainfall and pumping.

State Agricultural and Mechanical College system.—The irrigation plant belonging to the experiment station of the State Agricultural and Mechanical College is a pumping plant deriving the necessary power from a windmill and a gasoline engine. The windmill is a steel Ideal, the original pump a deep-well pump having a maximum capacity of 80 cubic feet an hour. But this required a high wind to maintain the flow, and a 5½-horsepower (nominal) Weber & Co. gasoline engine, capable of exerting 4 actual horsepower was added. The pump has a cylinder 3½ inches in diameter by 36 inches long, with a

24-inch stroke when run by the engine and a 9-inch stroke when run by the windmill. The water is forced 600 feet to a reservoir 16 feet above the top of the well. The reservoir is 32 feet long, 52 feet wide, and 8 feet deep, and will hold about 100,000 gallons, 0.3 acre-foot. It was built by excavating to a depth of 4 feet and building around the excavation earthen walls of the same height, the total cost being $140. On account of the very porous nature of the soil all tanks in this region must be lined with artificial material—cement, asphalt, or coal tar. The reservoir at the experiment station is lined with a mastic consisting of 73 per cent sand, 25 per cent coal tar, and 2 per cent lime. The sand and lime are mixed together and the tar is boiled until it will string, when it is mixed hot with the other ingredients, and while hot is spread on the bottom and sides at the rate of 52 pounds to the square yard. On top is put a varnish formed by boiling pure coal tar and flashing it with a lighted match to burn off the light oils. The plant was completed in 1897, and it is estimated that 20 acres can be served by it. Gasoline costs 16 cents a gallon in Beeville, and 1 gallon used as fuel for the engine delivers about 1,900 gallons to the reservoir under the conditions stated. The cost of water per 1,000 gallons is 8.42 cents. Calculating the cost of a single irrigation at this rate, assuming that 2 acre-inches are supplied, 54,309 gallons (2 acre-inches) cost $4.58 per acre per application, or at the rate of $2.29 per acre-inch. Should land be permitted to become very dry before irrigation is resorted to the cost is increased correspondingly. Early in 1901 there was added to this plant a larger pump (5¾-inch cylinder), the capacity of which is 70 gallons an hour. A new well has been sunk 12 feet from the old well, the two being connected 60 feet beneath the surface of the ground, so that the water of one well will supplement that of the other well.

McDowell system.—W. G. McDowell, of Beeville, has a plant consisting of a 1½-horsepower gasoline engine pumping from a 70-foot well and irrigating 5 acres.

Beeville irrigated gardens.—These gardens have the most efficient plant near Beeville. It consists of a 4-horsepower gasoline engine pumping into a reservoir of 140,000 gallons capacity. Thirteen acres of vegetables are irrigated, but the plant could easily irrigate 20 acres.

Bee Star gardens.—The Bee Star gardens, of Skidmore, operate a plant consisting of an engine of 4 horsepower and an Ames pump with 4-inch suction pipe. The water is pumped from a 6¼-inch well 110 feet deep, and is discharged into a reservoir 120 feet in diameter, having a capacity of 500,000 gallons. Fifty acres of cauliflowers, cabbages, cantaloupes, etc., are irrigated. By judicious management of the water 100 acres could be irrigated.

Other truck systems.—The foregoing are types of many other systems in the country around and near Beeville. These plants generally consist of a small engine, a centrifugal pump, a surface reservoir, and the necessary ditches. The following plants are in successful operation: S. A. McHenry (two plants), 27 acres; Carl Rankin, 12 acres; J. T. Holliday, 12 acres; J. K. Robertson, 7 acres; W. D. Messinger, 3 acres; A. M. Stoval, 12 acres; R. I. Eidson, 12 acres; J. H. Elliott, 4 acres, J. M. Chittim (near Normanna), 15 acres; James McCan (near Victoria), 25 acres.

Near Driscoll, in Nueces County, Charles Reynolds, George Reynolds, and Will Shealy are installing plants similar to the foregoing, while P. E. McNeill and John Clementson, at Wade's station, have each a plant in operation. The latter plants obtain the water from wells 150 and 190 feet deep, respectively, and during the current season 25 acres were irrigated.

King system.—On the King ranch, south of Alice, 46 artesian wells, of an average depth of 500 feet, furnish abundant water, and Mr. R. J. Kleberg, the manager, has commenced using this water for the irrigation of alfalfa; but this system is at present in its infancy.

Landa system.—Mr. H. Landa has just installed two irrigation plants on Comal River, at New Braunfels, for the purpose of irrigating about 70 acres of farm land. In one case the water is pumped from a lake near his flour mills and is forced through about 370 feet of 10-inch pipe into a canal in the field, being conducted through the canal to the highest point on the farm and then distributed by means of laterals to all parts of the tract. Intermediate laterals are also constructed at intervals along the main canal, and the water is carried by gravity to all minor elevations, the surface of the water in the main canal being higher than any point in the field. This system will water 25 or 30 acres. Mr. Landa's second system is supplied by a pump operated by a 20-horsepower gasoline engine, the water being elevated into a flume which leads into a canal that terminates on the bank of the river. This canal is constructed on the same principle as the one just described, the water being conducted to the highest portion of the field and distributed by means of laterals at intervals along its course. The tract to be irrigated by this canal contains about 40 acres. The canals are about 10 feet wide and the laterals 5 feet wide, constructed by building two parallel levees 10 feet apart, of sufficient thickness to prevent much seepage, the tops or crowns of the levees being made level, forming an elongated reservoir across the field, from which the water can be drawn at will. The total length of the main canal in the first system is 1,700 feet, the total length of the laterals 1,100 feet. The total length of the main canal in the second system is 2,200 feet, the total length of the laterals 2,700 feet. In the first case the water is raised 4 feet from the tank into the canal.

Locke system.—One mile west of New Braunfels Otto Locke irrigates 33 acres in orchards, nurseries, corn, potatoes, etc. A 12-horsepower Foos gasoline engine operates a 6-inch centrifugal pump against a lift of 47 feet, raising 400 gallons per minute. The discharge pipe conveys the water to the highest point of the land, from which it is distributed by ditches to the lands watered. With the present prices of gasoline it costs \$7 an acre per season. If continuously operated the plant could irrigate 50 acres.

Lenzen system.—The plant of G. P. Lenzen is located on the north bank of the Comal River in the suburbs of New Braunfels, and was first operated during the season of 1902. A 20-horsepower gasoline engine, operating a 6-inch Van Wie centrifugal pump against a lift of 60 feet, delivers the water into a 12 by 12 inch flume 500 feet long. Sixty acres in peas, sorghum, corn, cotton, and potatoes are irrigated at an average cost of \$7 per acre.

Fischer system.—On the east side of the Guadalupe River, 1 mile below New Braunfels, near the bridge of the International and Great Northern Railroad, C. F. H. Fischer installed late in the season of 1902 a water-power irrigation plant. A dirt dam across the north channel of the Guadalupe deflects the water under a 7-foot undershot wheel, which operates a 3-inch Gould pump against a lift of 60 feet. The plant at present writing is an embryo of what is intended. A reservoir is to be constructed, and from this water is to be drawn to irrigate 50 acres in corn, cotton, grass, and gardens.

Bruemmen system.—One and one-fourth miles northeast of New Braunfels, W. Bruemmen uses an 8-horsepower Model gasoline engine to operate a centrifugal pump against a lift of 51 feet. The water is pumped out of the Guadalupe into a flume 1,100 feet long, which carries the water to the highest point of the 18 acres that are irrigated. The plant was put in late in the season of 1902, and its capacity has not been fully tested, but it has been found that it costs only \$1.80 per day to operate the complete plant.

Starty system.—One mile north of New Braunfels, A. G. Starty has a small pump plant that derives its water from a well. A 6-horsepower gasoline engine runs a 4-inch Van Wie pump against a lift of 20 feet. The plant is located in the lowlands north of Landa Park, and during the current season 8 acres in cane, corn, and cotton were irrigated.

Dittmar system.—Five miles below New Braunfels, on the west side of Guadalupe River, Adolph Dittmar has a water-power irrigation plant. The water is pumped from the river by a Worthington pump having 10-inch discharge and a lift of 40 feet. The power is generated by one Risdon turbine working under a head of 5 feet. The dam is a natural formation in the river.

San Marcos Water Works Company system.—The San Marcos Water Works Company (William Green, president) transfers, by electricity, the power for its pump from a dam across San Marcos River, near the head of the stream. The distance from the water-power plant at the dam to the pump is 1,400 feet. The pump is a Van Wie centrifugal, having 18-inch discharge. The lift is only 8 feet, and it is the intention to bring 185 acres under irrigation.

Freeman systems.—About three-fourths mile below San Marcos, on the east side of the river, I. Freeman has a 16-horsepower gasoline engine which operates a 6-inch Morris centrifugal pump under a lift of 26 feet. The capacity is 1,312 gallons a minute, which would require only 8 horsepower. One hundred and twenty acres are to be brought under irrigation and cultivated in truck gardens.

J. R. Freeman has a 6-horsepower gasoline engine that runs a 4-inch Morris centrifugal pump, working under a lift of 26 feet. The estimated capacity is 350 gallons a minute. The plant cost $675. Ten acres of vegetables are irrigated.

Glover system.—The plant of Frank Glover consists of a 35-horsepower gasoline engine and a 12-inch Van Wie pump, operating against a lift of 35 feet. The water is pumped from San Marcos River, and it is intended to irrigate alfalfa and other crops. The soil is black and rich, and will produce well. The plant will irrigate 100 acres in 1902.

Lowman system.—Near the town of Staples, on San Marcos River, R. J. Lowman has a small irrigation plant in operation. The water is elevated to a height of about 21 feet, by means of an undershot water wheel carrying buckets on its circumference. The power is obtained from a 9-foot dam across the river. The capacity of the wheel is 300 gallons a minute. At present only 3 acres (a truck garden) are irrigated, and the wheel is not used to its full capacity.

Jones system.—About 5 miles below San Marcos, on San Marcos River, J. C. Jones irrigates a farm of 20 acres by means of the power obtained from a 7-foot milldam. He uses a 6-inch centrifugal pump having a capacity of 1,000 gallons a minute and one 2-inch rotary pump having a capacity of 125 gallons a minute. The water is lifted to a height of 31 feet. Part of it is pumped into a reservoir in the field, and the remainder is run directly from the pump to the field and there distributed. This is the first year the farm has been irrigated. The crop is to be corn and alfalfa. Cost of plant, $600.

Undershot water wheels.—Near San Marcos irrigation on a small scale is practiced by the use of undershot wheels, of wood, of the simplest form, with a metal bucket fastened to the perimeter of one side of the wheel in front of each paddle. These buckets fill in succession as the wheel turns and empty into a trough above, thus raising the water to a height of very nearly the diameter of the wheel. The wheel owned by Capt. John Richards irrigates 2 acres of grapes and vegetables, while that of D. C. Garret irrigates 7 acres.

SYSTEMS ALONG LOWER NUECES RIVER, LOWER RIO GRANDE, AND LEONA RIVER.

Nueces River rises in the Edwards Plateau and, with its tributaries, the Leona and the Frio, drains the portion of Texas between Brackett, San Antonio, Corpus Christi, Encinal, and Carrizo Springs. In this paper "the Lower Rio Grande" refers to the portion of that river below Del Rio. The irrigation systems along the Nueces and its tributaries above the Southern Pacific Railroad are included in those of the Edwards Plateau.

LOWER NUECES RIVER.

Dolan system.—Going upstream, the first irrigation system is that of Pat Dolan, which is 6 miles below the crossing of the Southern Pacific Railroad. It consists of a 15-horsepower gasoline engine operating a pump, and with it he irrigates his garden and orchards. The cost of the plant was $735, and at the time of its erection gasoline was selling at 12 cents a gallon, and he says that irrigation under those circumstances could be made to pay.

COTULLA AND VICINITY.

Near Cotulla there are seven very effective pump-irrigation systems:

Copp system.—The plant of George Copp is the oldest, and originally cost $1,000. It consists of a 12-horsepower duplex steam engine and a 4-inch discharge pump, which, working against a lift of 45 feet, has an estimated capacity of 330 gallons a minute. The water is pumped from Nueces River and is delivered through 3,000 feet of pipe. The chief crop is Bermuda onions. It costs from $15 to $25 an acre to irrigate, depending upon the season. The yield is from 15,000 to 30,000 pounds an acre, and as the onions command from 1½ to 4 cents a pound the revenue is from $225 to $600 an acre. In all Mr. Copp irrigates 150 acres.

Butler system.—W. P. Butler's plant irrigates 10 acres by the use of a 4-horsepower gasoline engine and a centrifugal pump having a 3-inch discharge pipe. The water is pumped from Butler Lake and from Nueces River, and is raised 31 feet through 600 feet of delivery pipe. The system cost $700. The principal crop raised is Bermuda onions. The yield per acre and the price commanded are the same as in the case of Mr. Copp. Without rainfall the onions must be irrigated every fifteen days, while cabbages require water only once a month.

Kaley & Fuller system.—The plant of Kaley & Fuller consists of a 50-horsepower steam engine and a centrifugal pump having a 3-inch discharge. Water is pumped from Nueces River against a head of 26 feet. The estimated capacity is 600 gallons a minute, and 30 acres of Bermuda onions and cabbages are irrigated. The cost of the plant was $1,200. The yield and the revenue are the same as from the plants previously mentioned.

Uhl system.—The plant of Alexander Uhl cost $1,200, and consists of a 12-horsepower steam engine and a centrifugal pump having 6-inch discharge, operating against a lift of 28 feet. The capacity is estimated at 500 gallons a minute, and 35 acres of Bermuda onions are irrigated. The water is pumped from Harris Lake and from Nueces River, and is delivered through 1,150 feet of pipe.

Davis system.—The plant of J. H. Davis consists of a 12-horsepower steam engine and a duplex pump costing $1,000, and irrigates 100 acres of onions and tomatoes. The water is pumped from Nueces River, and is delivered through 2,000 feet of pipe. The capacity of the plant is estimated to be 200 gallons a minute.

Seafeldt system.—The plant of H. G. Seafeldt consists of a 15-horsepower steam engine and a duplex pump having a 4½-inch discharge, and irrigates 150 acres. Principal crop, Bermuda onions.

Hargus & Poole system.—The plant of Hargus & Poole consists of a 12-horsepower steam engine and a duplex pump having a 6-inch discharge. The plant cost $800. Water is pumped from Nueces River and is delivered through 500 feet of pipe.

UVALDE.

Kilgore system.—Six and a half miles west of Uvalde, on the left bank of Nueces River, is the plant of M. H. Kilgore and associates. A 55-horsepower engine operates a centrifugal pump, which delivers 1,500 gallons a minute (3⅓ second-feet) against a head of 73 feet. Wood is used as fuel, and as it is plentiful, the cost is nominal. The main ditch is 2 miles long, 6 feet wide at top, 2 feet at bottom; average depth, 2 feet. The plant was started in 1901, and 250 acres of the black, waxy, and sandy loam, most of it in alfalfa, were irrigated.

IDLEWILD.

Masterson system.—Near Idlewild, on the Southern Pacific Railroad, Branch T. Masterson has installed a pumping plant on Medina River. Steam is supplied from a 60-horsepower boiler, which operates the gin and mill, while the pump (8 and 12 by 12 by 10 inches) is connected direct. The head is 50 feet. The system was installed in the spring of 1901, and 200 acres, in oats and cotton, were irrigated. Medina River flows only about half of the year, but the plant is near a large pool in the river, which will furnish a supply at low stages.

CARRIZO SPRINGS AND VICINITY.

J. S. Taylor system.—Two miles below the iron bridge across Nueces River, on the road from Cotulla to Carrizo Springs, J. S. Taylor operates a pumping plant consisting of a 25-horsepower Buckeye engine, a 30-horsepower boiler, and an 8-inch centrifugal pump having 6-inch discharge. The lift is 25 feet, and 60 acres of onions, corn, and oats are irrigated. The water is pumped into a surface reservoir of about 2 acres area, located about 300 feet from the pump. The ditch leading from the reservoir to the field is one-fourth mile long. The pump is 100 yards above the dam mentioned below.

M. A. Taylor system.—On the ranch of M. A. Taylor a dam has been constructed across Nueces River about 2 miles below the iron bridge just referred to. The dam is 20 feet high in the center and 34 feet high on each side; wasteway 50 feet; length of dam about 170 feet. The dam is of live-oak log cribs filled with stones and backed with stones, cement, gravel, and clay. The lake at low water is 20 feet deep and 5 miles long. To run the water out on gravity the dam would have to be built 29 feet high, which would give the water in the canal a total fall of 3 feet. The dam can be built 35 feet high, which would give a storage head of 9 feet, and would make a lake 10 miles long. The canal would be 1 mile in length and would turn the water out on gravity about 1 mile southeast of the ranch house. A storage dam 12 feet high and 200 feet long is to be constructed about three-fourths of a mile north of the soldier stone bridge, which would create a lake 10 feet deep and 10 miles long. To increase the height of the present dam to 29 feet in the center and 40 feet on each end, making it about 500 feet long, and to build the mile of canal 6 feet wide on bottom and with a slope of $\frac{1}{2}$ to 1, would cost $6,000.

Artesian-well systems.—At Carrizo Springs artesian water can be obtained at a depth of about 100 feet. Artesian-well irrigation, however, is in its infancy. The wells 100 feet deep have a slow flow, although those of greater depth show a largely increased flow. The Paterson well is 590 feet deep and has a flow of about 200 gallons a minute, while the Campbell well, 5 inches in diameter, has a depth of 350 feet and a flow of 50 gallons a minute. These wells have not yet been used for irrigation, as they were completed late in 1901. Mr. Campbell has installed a 15-horsepower gasoline engine and a 5-inch centrifugal pump to augment his supply, and has constructed two earth tanks having a total area of 2 acres and an average depth of 8 feet. A well with a flow equal to the Patterson well could irrigate, under economical distribution, from 50 to 100 acres, depending on the season.

The Carrizo Springs.—No attempts have been made to utilize the flow of the famous Carrizo Springs for either power or irrigation.

LEONA RIVER.

The behavior of Leona River has been very irregular for several years. The Leona Spring, the source of its supply, is in the suburbs of Uvalde. It was dry in 1885, but soon revived and continued flowing until 1893, when it again stopped and has not flowed since. In 1893, before the spring ceased to flow, a pumping station for the city water supply was built on the banks near the spring, but a year or two after the spring failed, the pumping plant was transferred to its present location, within 150 yards of the court-house. At the new station a pit 15 feet by 15 feet by 24 feet deep was excavated, and the pumps were placed in its bottom. A well 4 feet by 7 feet was sunk in the bottom of the pit to a depth of 16 feet, or to the 49-foot level below the surface of the ground, from which water was pumped to a standpipe. At first the water rose in the well to within 35 feet of the surface, but in December, 1897, it was noticed that the supply was failing, and it continued to fail until May, 1898, when a second pit

10 feet by 10 feet by 9 feet deep was excavated on the southwest side of the first or main pit, and in it a well was sunk until its bottom was 63 feet below the surface. The pumps were then placed in the second pit, making their position about 33 feet below the surface. In January, 1899, however, the water level had fallen so low that it was necessary to bore in the pump well three wells of a depth of from 30 to 35 feet, reaching a total depth of 98 feet below the surface.

In June, 1899, after the heavy rains over southwestern Texas, known as the Brackett flood, the water was standing at about the 93-foot level and was slowly rising. On September 16, 1900, the water had risen to within 2 feet of the pumps, or to the 35-foot level. In other words, in fifteen months the water had risen about 58 feet, or nearly 4 feet a month. It continued to rise, and on December 1 had reached the pumps and arrangements were made to raise them. Accurate measurements during September, 1900, showed that the water was at that time rising in the wells at the rate of 4 inches a month.

Between the Leona Spring and the brickyard crossing, on the road from Uvalde to Pearsall, there are several small springs which contribute to the flow of the river, the largest being the Mulberry Spring. During the early part of 1900 this spring was flowing, but in September of that year its flow had ceased. On December 1, however, it had a flow of about 1 second-foot. In 1895 the discharge of Leona River at the brickyard crossing was 11 second-feet, but in June, 1899, the river was dry at the ford, and there was no water flowing between Uvalde and old Fort Inge, 4 miles below. On December 17, 1900, the flow at the brickyard crossing was 5 second-feet.

There are a number of irrigation systems along the river.

UPPER DITCH.

In 1874 a dam of dirt and logs was constructed across the river near old Fort Inge. It had a length of 53 feet and a height of 6 feet. The ditch known as the Upper ditch was taken out on the east side, the topography being such that a deep cut had to be made in the bank of the river. In all there are about 5 miles of ditches in this system, of the usual depth of 6 feet and of a width of 4 feet. Six hundred and thirty acres are irrigated from it. The crops raised are corn, hay, cotton, and onions. The yields per acre are 30 bushels of corn, 4 tons of hay, 1 bale of cotton, and 15,000 pounds of onions.

LOWER DITCH.

The Lower ditch was constructed in 1871. It is 4½ miles long, 6 feet wide, and generally about 3 feet deep. A dirt-and-log dam 50 feet long and 6 feet high forces the water into the ditch. The soil is a rich sandy loam. Three hundred acres are irrigated, the crops being corn, hay, and cotton. The yield is about the same as along the Upper ditch.

COMANCHE IRRIGATION COMPANY'S DITCH.

In Zavalla County, $2\frac{1}{2}$ miles above Batesville, the Comanche Irrigation Company has taken out a ditch on the west side of Leona River. (See fig. 16.) It is $2\frac{1}{2}$ miles long, 7 feet greatest depth, and 4 feet wide. The dam that deflects the water into the ditch is about 100 feet long and 15 feet high, and was first constructed in 1876, but had to be rebuilt. The ditch at first runs due west from the lake formed

FIG. 16.—Map of Comanche Irrigation Company's ditch near Batesville.

by the dam for a distance of about 1 furlong, and then curves to the south, and for 2 miles runs almost parallel with the river, and then branches, in order to bring more land under it. The soil is a dark sandy loam of great depth, rich and easily cultivated, and is known as black mesquite. The company irrigates 500 acres of corn, oats, cane, hay, cotton, fruits, and garden truck. The corn yields 35 bushels and the cotton 1 bale to the acre.

LOWER RIO GRANDE.

The Rio Grande Valley forms one of the most inviting fields for irrigation on a large scale that can be found in Texas. At Brownsville the valley is 35 miles wide, decreasing slightly upstream toward Hidalgo. Five miles above Hidalgo the width suddenly decreases, and from there on it varies considerably, being at most a few miles and often almost nothing. There are from 180 to 200 square miles of rich and fertile valley land that could be brought into active production by clearing up the land, constructing canals, and installing pumping machinery. The minimum flow of the river at Laredo is 2,500 second-feet, and remembering that 1 cubic foot per second will irrigate and keep flooded 50 acres of rice, it can readily be seen that the natural factors of soil and water only await utilization to inaugurate a successful rice and sugar industry along the Rio Grande. Sytems have already been built near Eagle Pass, at North Laredo and Hidalgo, and at Brownsville and vicinity, as described on the following pages.

EAGLE PASS.

Dolch system.—Just below Eagle Pass L. F. Dolch has put in a large pumping plant with which he will irrigate 400 acres of the Rio Grande bottoms. His machinery consists of a 125-horsepower Frost engine and two 80-horsepower boilers, operating two centrifugal pumps of 14-inch discharge against a lift of 45 feet. The estimated capacity is 22 second-feet. The plant is on the banks of the river, the pumps being in a pit 31 feet deep and 20 feet in diameter. The water is drawn from the river through a 14-inch suction pipe 300 feet long, and is discharged through 1,100 feet of 14-inch discharge pipe.

NORTH LAREDO.

In North Laredo, on the banks of the Rio Grande, there are three pumping plants for irrigation.

Nye system.—The plant of F. C. Nye consists of two 60-horsepower boilers and a Quincy duplex pump having a capacity of 800 gallons a minute (1.8 second-feet) against a head of 65 feet. The water is pumped from a well on the sloping banks of the river. The well extends below the level of low water and is connected to the river by a pipe. It is well built, about 12 feet in diameter, and is lined with brick. The pump is on a platform in the well. Only 12 acres are irrigated, but 75 acres could easily be served. The pumps are usually operated eleven hours a day, at a cost of $7.50 for repairs, coal, engineer, etc. The fuel used is the Pecos coal, which costs $1.50 a ton. The land is watered twice a month, and the yield is 21,000 pounds of onions to the acre for unfertilized land and 31,000 pounds to the acre for fertilized land.

Lithgow system.—The plant of F. H. Lithgow is about a half mile below the Nye plant, and consists of a 20-horsepower gasoline engine and an 8 by 10 Van Wie triplex pump, which has a capacity of 400 gallons a minute against a head of 70 feet. The water is delivered through a pipe 830 feet long. The cost, including oil, is $3.25 per day of eleven hours. The engine runs without supervision and can water 30 acres a day. The soil is alluvial, 10 feet deep, underlain with clay. The crops raised are onions, tomatoes, cabbages, carrots, turnips, watermelons, and cantaloupes. In all 38 acres are irrigated.

Madrigal system.—The plant of S. V. Madrigal, which adjoins the Lithgow plant, consists of a 10-horsepower Weber gasoline engine and a 6 by 8 triplex pump raising 200 gallons a minute against a lift of 70 feet. One acre a day is irrigated, and each section of land is watered every twelve to fifteen days. The pump is an upright direct-stroke and is operated by a belt from the engine. The suction pipe is a 4-inch, and the water is pumped from a well connected with the river similarly to that of the Nye plant. The well is 5 by 5 feet and is lined with timber.

HIDALGO.

Closner system.—At Hidalgo, down toward the mouth of the Rio Grande, is a steam pumping plant owned and operated by John Closner. It consists of a 50-horsepower engine operating a centrifugal pump having a capacity of 6.7 second-feet. The water is pumped from the Rio Grande, and 200 acres of sugar cane and corn are irrigated. The principal crop is sugar cane, which is manufactured into sugar that finds a ready market. This plant has proved one of the most successful in Texas, and it is paying an excellent return for the outlay.

BROWNSVILLE AND VICINITY.

Brulay system.—George Brulay, of Brownsville, has a pumping plant worthy of attention. Is is 8 miles below Brownsville, in Cameron County, and was completed and first used in 1896. It consists of two boilers, having an aggregate capacity of 100 horsepower, and a 45-horsepower Morris centrifugal pump, having a maximum capacity of 8,000 gallons a minute, or 17.82 second-feet. The total lift is 22 feet, and when in use the pump is run about fourteen hours a day. It is designed to cover 300 acres, but so far only 240 acres, planted in sugar cane, have been irrigated. A high-grade sugar is made from the cane juice.

Goodrich systems.—E. H. Goodrich reports having installed a 10-horsepower Priestman engine in a resaca on his place, 6 miles north of Brownsville, in March, 1897, but he has used it very little, owing to favorable weather and to the fact that the ditches are not yet finished. With two 12-foot windmills on the same place he can irrigate 35 acres. He also irrigates between 15 and 18 acres on his place, 3 miles north of Brownsville, by means of a 14-foot windmill pumping from a well in the bank of a resaca. The distance to the water varies from 5 to 12 feet, and the pumps, which are three in number, discharge into a flume connected directly with the ditches. The total cost of the latter plant was $300.

Tijerina system.—Tomas Tijerina, Sabos Cavazas, and Pedro Cerna, on a farm about 9 miles above Brownsville, raise sugar cane by subirrigation from the Rio Grande. The cane is ground in an old-fashioned sugar-cane mill, and the juice is caught and boiled down to a consistency that will readily mold. The molds are of the form of a frustum of a cone of about 4 inches base. After the sugar is molded it is known as *piloncillo.* It is $\frac{98}{100}$ pure sugar, is hard, breaks readily, and the light varieties have a taste similar to that of maple sugar. The lumps are wrapped in the foliage of the cane and are put up in packages of 150 pounds, forming what is called a cargo, equal in volume to six American bushels. *Piloncillo* is one of the chief commodities of the Mexicans of the Lower Rio Grande.

COLORADO VALLEY SYSTEMS.

The irrigation systems in this section include those in the Colorado Basin which are within a short distance of the river or immediately upon it. The Edwards Plateau is drained on the north by the tributaries of the Colorado, but the irrigation systems on those tributaries are described in the Edwards Plateau group, pages 25 to 51.

STERLING COUNTY.

The first systems along the Colorado or its branches are in Sterling County, along the North Concho. There are two of them, one owned by the McGee Irrigation Company and the other by J. N. and J. H. Kellis.

McGee Irrigation Company system.—This plant is 5 miles from Sterling City. The main ditch is on the southwest side of the river. It is 2 miles long, has a top width of 6 feet, a bottom width of 4 feet, and carries about 1 foot of water. It was begun in 1892 and was first used in 1894. The water is raised by a loose-rock dam 125 feet long and 6 feet high, built across the river. The total cost was $1,500, and it commands 250 acres, only 70 of which are irrigated. The principal crops, in order of their importance, are cotton, corn, sorghum, oats, sweet potatoes, alfalfa, and vegetables. The ditch is kept in repair by each stockholder doing his share of the work.

Kellis system.—The Kellis plant was constructed in 1889 on the northeast side of the North Concho. The ditch is 1 mile long, top width 6 feet, bottom width 4 feet, depth 2 feet. The water is deflected into the ditch by a loose-rock dam 50 feet long and of an average height of 5 feet. The soil irrigated is a loose gray loam. Fifty acres are served from the ditch, the crops being cotton, corn, cane, oats, potatoes, and Johnson grass.

IRION COUNTY.

Near Sherwood, in Irion County, there are three dams across Spring Creek, the headwaters of Concho River. These are known as the upper, the middle, and the lower dam, and, although injured considerably by the floods of 1900 and 1901, each dam has its irrigation system in the chocolate-colored loam of the river valley. The upper and middle dams are 3 and 2 miles, respectively, above Sherwood. The ditches from them irrigate 266 and 216 acres. The lower, or Steinbaugh dam, is a half mile from Sherwood, and the ditch from its reservoir irrigates 153 acres. The crops raised command the highest market price, as competition is practically out of the question. The Sherwood system commands in all 635 acres.

TOM GREEN COUNTY.

In Tom Green County the irrigation facilities furnished by Concho River and its numerous branches and tributaries are among the best to be found anywhere in western Texas. These have been only partially utilized, however, in separate systems, by individuals and small companies, making the cost of maintenance much greater than if consolidated. Nevertheless they have been fairly successful, and have certainly reduced the cost of living in that section, making foodstuffs, especially vegetables, much cheaper and more abundant. Eleven plants are reported in the county—six on the South Concho, one on the North Concho, one on Lipan Creek, and one each on Spring Creek and Dove Creek. The location of all of these ditches, except the one on the North Concho (the Williams or Joe Glenn ditch) and the one on Lipan Creek (the Kelly ditch), is shown in fig. 17. The total area irrigated in the county is 3,500 acres.

Williams or Joe Glenn ditch.—The ditch of Mrs. W. D. Williams, known as the Joe Glenn ditch, is on the North Concho, 1½ miles west of Water Valley. It is 3 miles long, 8 feet wide on top, 4 feet wide on bottom, and 2½ feet deep. It was first used in 1886, and is supplied with water by a rock dam across the river, 100 feet long and of an average height of 8 feet. The total cost of the system was $3,500, and it commands 350 acres, 225 of which have been irrigated, two-thirds in cotton and the remainder in different sorghums and oats.

Glenmore farm ditch.—Two miles southeast of San Angelo is the celebrated Glenmore farm, sometimes known as the Cunningham farm, owned by A. F. Mabry. In 1891 a timber dam of the kind known as "turtle back," 74 feet long and of an average height of 7 feet, was built across the South Concho, and from it a ditch 4 miles long and of an average width of 6 feet and an average depth of 14 feet conducts the water to the land irrigated. The dam cost $4,000 and the ditch $500 a mile. The soil is a black sandy loam, and alfalfa, celery, cotton, and garden truck are produced in abundance. About 20 acres are confined to a garden. The famous Glenmore celery is produced here. Ninety acres are irrigated, and the yield of alfalfa is 4 tons to the acre.

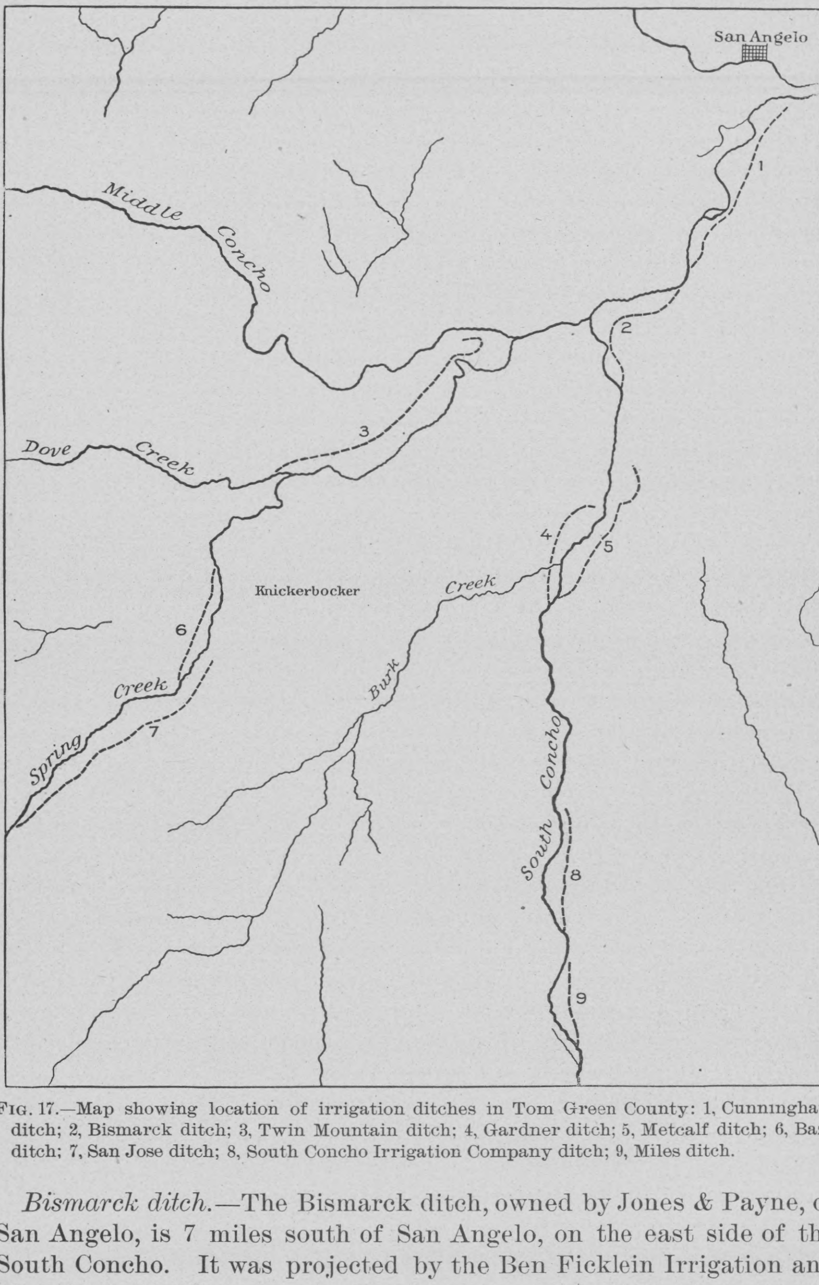


FIG. 17.—Map showing location of irrigation ditches in Tom Green County: 1, Cunningham ditch; 2, Bismarck ditch; 3, Twin Mountain ditch; 4, Gardner ditch; 5, Metcalf ditch; 6, Baze ditch; 7, San Jose ditch; 8, South Concho Irrigation Company ditch; 9, Miles ditch.

Bismarck ditch.—The Bismarck ditch, owned by Jones & Payne, of San Angelo, is 7 miles south of San Angelo, on the east side of the South Concho. It was projected by the Ben Ficklein Irrigation and Manufacturing Company, and was constructed in 1875. It is 4 miles long, 10 feet wide, and of an average depth of 2.9 feet. A brush-and-rock dam 80 feet long and 10 feet high deflects the water into the ditch. The dam cost $1,500 and the ditch cost $900 a mile, the total cost being about $5,000. The soil is black loam; the crop raised oats, corn, cotton, sorghum, and Johnson grass. The yield per acre is 60 bushels of oats, 20 bushels of corn, two-thirds of a bale of cotton, and 3 tons of hay. Six hundred acres are irrigated. The most modern methods are used on this farm. The ground is plowed by use of a 20-horsepower traction engine, which, with three disk plows, breaks up 25 acres per day. Two crops are often raised on the same land in one year. When the small grain is cut, a crop of turnips is immediately planted, and these are off in time for small grain in the fall.

Gardner system.—The plant of A. F. Gardner is on the west side of the South Concho, 12 miles south of San Angelo. A dam of brush and rock 70 feet long and 6 feet high, costing $400, was constructed in 1883. It deflects the water into a ditch 2 miles long, 6 feet wide, and of an average depth of 16 inches. The ditch cost $250 a mile, making the total cost of the system $900. In all 70 acres of sandy loam are irrigated. The crops are oats, cotton, and Johnson grass, the yield being 60 bushels of oats, two-thirds of a bale of cotton, and 3 tons of grass to the acre.

Twin Mountain ditch.—The Twin Mountain ditch is on the north side of the river, at Spring Creek, 12 miles southwest of San Angelo. It is owned by Charles Mott, of San Angelo. A wooden dam 80 feet long and 7 feet high, built in 1885 at a cost of $2,000, deflects the water into the ditch, which is 3 miles long, 12 feet wide, and 15 inches deep, and cost $500 a mile. Under this system 300 acres of black loamy land are irrigated. The crops are oats, cotton, and Johnson grass, the yield the same as elsewhere in this locality.

Metcalf ditch.—The Metcalf ditch (owned by Metcalf & Sims) is 12 miles south of San Angelo, on the east side of the South Concho. It is 4 miles long, with an average top width of 12 feet, a bottom width of 8 feet, and a depth of water of 1½ feet. It was begun in 1887, and the first mile was completed the next year, but the ditch was not entirely completed until 1896. It takes water by means of a brush-and-stone dam 200 feet long and 7 feet high, which extends across the river. The cost of the dam was about $500, the cost of the main ditch $500 a mile, and the cost of the laterals, of which there are three, $250 a mile, making the total cost, with incidentals, $7 to each of the 470 acres now irrigated. The repairs, which are maintained by the tenants, may be estimated as amounting in labor to 75 cents an acre. The crops are Johnson grass, cotton, corn, oats, wheat, and garden truck.

South Concho Irrigation Company ditch.—The plant of the South Concho Irrigation Company was constructed in 1881. It is on the east side of the river, 20 miles south of San Angelo. The brush-and-rock dam is 70 feet long and 7 feet high, and cost about $600. The ditch is 3 miles long, 7 feet wide, and averages 16 inches in depth. It cost $400 a mile. The soil is rich, black loam, and the 220 acres irrigated yield 60 bushels of oats and 3 tons of Johnson grass per acre.

San Jose Irrigation Company ditch.—The dam of the San Jose Irrigation Company (of which Joseph Tweedy, of Knickerbocker, Tex., is the secretary) is on Dove Creek, about 8 miles from Knickerbocker. It is composed of brush, rock, and gravel; is 900 feet long and 8 feet high, and cost about $1,250. The annual repairs cost from $50 to $100. The dam deflects the water into the ditch, which is 6 miles long, 8 feet wide, and 1½ feet deep, and cost about $300 a mile. The soil is chocolate-colored loam, and 1,400 acres are usually irrigated. The crops are oats, corn, cotton, sorghum, and Johnson grass, the annual yield per acre being 40 bushels of oats, 20 bushels of corn, three-fourths of a bale of cotton, and 3 tons of hay. This is by far the largest irrigation system in the Colorado Valley.

Baze irrigating ditch.—Five miles below the dam of the San Jose Company and 3 miles from Knickerbocker is the dam which feeds the Baze irrigating ditch. This was constructed in 1875 and is now owned by Dr. Boyd Cornick and others. It is of wood and rock, 48 feet long, and 8 feet high, and cost about $500. The ditch is on the west side of the creek. It is 3 miles long, 7 feet wide, and 1½ feet deep. The soil is similar to that of the San Jose Company's tract. One hundred and sixty acres of oats, alfalfa, and cotton are irrigated.

Kelley system.—Twenty miles southwest of San Angelo, on Lepan Creek, is the system of Mr. W. S. Kelley. In 1894 he constructed a wooden dam 40 feet long and 4 feet high, which feeds the ditch. The latter is 1½ miles long, 4 feet wide, and about 1 foot deep. The soil is a sandy loam. Forty acres of oats, Johnson grass, and garden truck are irrigated. The dam cost about $150 and the ditch $175 a mile.

BROWN COUNTY.

Swinden Pecan Orchard Company.—Near Brownwood, in Brown County, about 120 miles east of San Angelo, there is a large area suitably located for irrigation on an extensive scale. In it is the plant of the Swinden Pecan Orchard Company, which consists of a centrifugal pump operated by an 80-horsepower engine, pumping 3,000 gallons a minute, or 6.84 second-feet. The water is carried by a flume 4,000 feet long to a reservoir formed by an earthern dam 400 feet long and of a height varying from 2 to 15 feet. The dam is at the foot of gently sloping land, and forms a triangular reservoir covering 55 acres. The reservoir is designed to irrigate the 400 acres of level land lying along the Pecan Bayou, from which the water is pumped to fill it. A small stream is also dammed and turned into the reservoir. The 400 acres commanded by the reservoir are planted in pecan trees, making the largest orchard of that kind in the world. The irrigation plant was put in chiefly to enable the owners to practice truck farming and the growth of small fruits between the rows of trees while waiting for the latter to mature. The soil is a rich black and chocolate colored loam. A great mistake was originally made in having the reservoir so large and shallow. Evaporation and seepage were in this way increased. To reduce the loss by evaporation an inside dam has been constructed, decreasing the area of the reservoir.

Fairland irrigated farm.—The Fairland irrigated farm, owned by J. F. Smith and brother, is a short distance from Brownwood. Two pumping plants have been installed. The first one consists of an Ivens single-suction centrifugal pump, operated by a 50-horsepower Chandler & Taylor plain slide-valve engine. With an average lift of 15 feet 4,000 gallons a minute (9 second-feet) can be discharged through the 10-inch discharge pipe. The second plant consists of an Ivens double suction pump having a 13-inch discharge pipe, and driven by an 80-horsepower Nagle engine, which delivers 5,000 gallons a minute (11 second-feet) against a head of 30 feet. The length of the ditches is about 4 miles, the width 6 feet at top and 3 feet at bottom, and the depth 1 foot. There are 400 acres under ditch, and $1\frac{1}{2}$ bales of cotton per acre are produced from irrigated land, while only one-fourth bale can be produced from unirrigated land. The first plant cost $2,000, the second plant $3,000, making a total of $5,000. In 1900 high water destroyed the crop.

MILLS COUNTY.

In Mills County several pumping plants were formerly operated along Colorado River, but the high water in June, 1899, and in April, 1900, damaged them by either submerging the pumps or destroying ditches and crops to such an extent that some of the owners were discouraged and never repaired the plants.

LAMPASAS COUNTY.

Finlan system.—One mile east of Lampasas Mrs. Owen Finlan for years operated a windmill plant, the water being pumped into a cement tank 60 feet in diameter. In 1901 a 4-horsepower gasoline engine was added. This plant is on the south bank of the Sulphur Fork of Lampasas River, and pumps the water from the pond or lake formed by Donovan's dam. The water is raised 20 feet by a bucket pump, and is delivered into a flume which conveys it to the cement tank. From the tank the water is conveyed to the land through a system of ditches. Fifteen acres of truck gardens are successfully irrigated. The yield of onions and sweet potatoes is exceptionally large. Below the plant of Mrs. Finlan there is a fertile valley that could easily be brought under ditch.

TRAVIS COUNTY.

Near Del Valle, in Travis County, there are two pump plants. That of George Begg consists of a 60-horsepower engine, which operates a 10-inch centrifugal pump against a lift of 45 feet; 200 acres in ordinary crops will be irrigated. The plant of N. H. Shappard consists of a 12-horsepower engine operating a 6-inch centrifugal pump against a lift of 40 feet. Only 20 acres were irrigated this season (1902), but plans have been formed to enlarge the system by adding a 45-horsepower boiler and two 10-inch centrifugal pumps.

SYSTEMS NORTH OF COLORADO RIVER.

Irrigation in this region is rare, for two reasons: (1) The section (the eastern portion) where the streams would furnish water for irrigation has sufficient rainfall to raise crops unaided; and (2) the western portion, including the Staked Plains, has no streams available for irrigation, the underground waters are still undeveloped, and the construction of impounding reservoirs has commended itself neither to private enterprise nor to public favor.

BELL COUNTY.

Hoover system—One mile west of Killeen, in Bell County, A. J. Hoover has shown what could be done by windmill irrigation. His plant consists of a Dandy windmill, 13 feet in diameter. The water is pumped from a pool 100 feet from the windmill, and is forced through 300 feet of 3-inch pipe into an earthen tank 50 by 100 feet, along the track of the Gulf, Colorado and Santa Fe Railroad. The water is elevated 14 feet. Five and a half acres of garden are irrigated. A ready market is found for all vegetables raised.

BURNET COUNTY.

There are three small systems in Burnet County, two from springs and one from the Colorado River. The latter receives its water from the dam of the Tanner Brothers, at Bluffton, and 30 acres are irrigated from this plant. Ten miles west of Burnet, Mr. Williams irrigates 15 acres in a truck garden, the water being obtained from a spring. A similar plant is located 10 miles south, at Marble Falls.

WILLIAMSON COUNTY.

There are a few small patches irrigated in the western and central part, but these consist of only a few acres. Early in 1902 H. T. Sterns installed a pumping plant 5 miles north of Taylor to irrigate ordinary crops. The water is derived from San Gabriel River by means of a 13-horsepower Charter gasoline engine operating a 3-inch Van Wie centrifugal pump. The dry-land corn around Taylor was burned up by the drought of 1902, and, as in the other central portion of Texas, it was cut for fodder. However, the irrigated corn of Mr. Stern afforded a severe contrast to the dry-land corn of his neighbors; while theirs was virtually burned up, his was as abundant as that grown on the best black land. The soil irrigated here is in the black waxy strip, which is known as the richest lands in Texas.

The few small systems referred to above are located along the San Gabriel and derive their water from springs. The plant of H. E. Townes is 8 miles west of Georgetown, and he irrigates 15 acres in tomatoes, sweet potatoes, beans, etc., from the old Knight spring. John Ischy, 4 miles west of Georgetown, irrigates a truck garden of 7 acres from the old Harper spring; while the plant of W. H. Donathan, 3 miles west of Georgetown, on the Middle Gabriel, irrigates his truck farm from a spring, in two levels, the lowest being irrigated from the ditches that lead from the spring, and the upper by means of a windmill that raises the water $3\frac{1}{2}$ feet.

MILAM COUNTY.

Near Cameron, Milam County, five pumping plants were installed somewhat late in the season of 1902. Four of these take their water from Little River and the other from a spring. The plant of McLane & Crain is 2 miles southwest of Cameron, on the southeast bank of Little River, and consists of a 100-horsepower boiler, a 75-horsepower engine, and an 8-inch Van Wie pump working against a lift of 27 feet. The farm consists of the rich black shell bottom lands, with an admixture of sand near the river banks. The San Antonio and Aransas Pass Railway passes through this farm on a high trestlework. The cotton and corn had just been watered when the August floods completely submerged a large part of the crop, killing corn and cotton and making the season's work a complete loss. The plant of J. M. Crain consists of a 10-horsepower engine and a 3-inch centrifugal pump working against a lift of 26 feet. However, no results were obtained, on account of the overflow mentioned above. The island farm of John B. McLane lies almost south of Cameron, on the south side of Little River, and its topography is such that the ditches have a good fall as they leave the river bank. A levee along the river bank above the pumping plant should be constructed to protect the lands from destructive overflows of the river. The present plant consists of a 20-horsepower engine which operates a 5-inch Van Wie centrifugal pump against a lift of 27 feet. There are 175 acres in the farm, and it is intended to add heavier machinery in order to increase the acreage. Just west of the city waterworks plant, on the north bank of the river, L. F. Blanchard has an irrigated truck garden of 20 acres. The water is obtained from the river by means of a 15-horsepower stationary steam engine which operates a 4-inch centrifugal pump. The land is very rich, and two crops are readily raised each season. The 6-acre truck garden of S. J. Brooks is a mile west of Cameron, and is irrigated from a reservoir directly. The water from a spring is piped to a fish pond, from which it is pumped into the ditches. The plant consists of a 2.5-horsepower Weber gasoline engine which operates a 2-inch rotary pump against a lift of 6 feet. The land irrigated was formerly an old quagmire.

STAKED PLAINS.

The Staked Plains is a great plateau, about 36,000 square miles in extent, with an almost flat surface which gradually rises from an elevation of 3,000 feet to 4,500 feet above sea level. Flowing water, except from a few springs, is almost unknown. The soil is of such a character that it readily absorbs the rain that falls upon it, which percolates downward and is reached in wells from 40 to 200 feet in depth. Many of these wells are capable of furnishing a supply almost inexhaustible to ordinary means of pumping. The soil is often too dry to be successfully cultivated without irrigation, which can be practiced only by means of water raised by pumps. Pumping, however, is most easily accomplished by means of windmills, which are remarkably successful in this region, owing to the almost constant winds which sweep across the plains. Windmills have been used for many years to furnish water for stock, and they have been tried successfully on a small scale for irrigation. The settlers of the plains have learned to appreciate the value of devices of this character for raising water. Reservoirs or tanks are almost always used in connection with the mills. The sides and bottoms of these are made impervious by turning in a little water and puddling the soil by driving horses or cattle about in it for a day or more.

Morrison system.—About the center of the Llano Estacado or Staked Plains, in Hale County, T. W. Morrison owns a plant consisting of two Aermotors, 8 and 12 feet in diameter, respectively, pumping from wells 50 feet deep, with water 20 feet below the surface. Each windmill lifts the water 35 feet. One wheel is used for supplying the residence; the other pumps into a reservoir 125 feet long, 100 feet wide, and 4 feet deep, and irrigates 10 acres, besides furnishing water for the stock. These wheels have been in use since 1891.

Wayland and Herbert systems.—J. H. Wayland, of the same county, has three Aermotors pumping from wells 35 to 60 feet deep into a reservoir 300 feet long, 75 feet wide, and 6 feet deep, irrigating 10 acres in 1901. The total cost of wells, pumps, wheels, and reservoir was $505. The total cost of the plant, which must include land and fencing, is given as $1,000. W. P. Herbert also irrigates 5 acres, and C. E. McClelland states that there are at least 50 families in Hale County prepared to irrigate by windmills from 5 to 20 acres if the season renders irrigation necessary, but for the last two years the seasons have been so good that irrigation has not been practiced.

SYSTEMS NORTH OF TEXAS PACIFIC RAILROAD.

There are hundreds of windmill plants north of the Texas Pacific Railroad. In the counties of Haskell, Shackelford, and Young, in fact in nearly all the counties east of the one hundred and first meridian, there are small garden patches, varying in size from one-sixth to three-fourths of an acre, irrigated by windmills. Fifty replies to letters sent out by the writer have not shown, with the exception referred to in these notes, a windmill plant that irrigated more than a half acre. Two windmill plants of Haskell County (those of W. H. Parsons and H. H. Nesbett) are typical of them all.

Parsons and Nesbett systems.—The plant of W. H. Parsons consists of a Dandy windmill 4 feet in diameter, pumping from a well and irrigating 1 acre. The plant of H. H. Nesbett consists of an Aermotor 10 feet in diameter and a 4-foot well 38 feet deep; depth to water, 31 feet. This wheel irrigates 3 acres of black, sandy soil.

Reynolds Land and Cattle Company.—The Reynolds Land and Cattle Company, near Channing, Hartley County, irrigates 40 acres from a spring. The principal crop raised is alfalfa, but a small orchard of fruit trees and a garden are also irrigated. The orchard consists of apples, peaches, pears, plums, and grapes. The underground water supply in the neighborhood of this ranch has not proved sufficient to irrigate more than small gardens.

Rathjen system.—F. H. Rathjen, of Mobeetie, Wheeler County, irrigates 60 acres of corn and alfalfa, from Williams Creek, which is fed by springs. The creek is 5 miles long and there is sufficient water to feed the quarter-mile ditch. The soil irrigated is a red loam.

Kempner & Lasker system.—Messrs. Kempner & Lasker have constructed a dam across Holiday Creek, about 5½ miles south and 20 degrees west of Wichita Falls. It is of earth, 3,000 feet long, 35 feet high in the creek, 25 feet high for 1,100 feet, and about 9 feet high at the north end. There are two wings, one 5,100 feet long and the other about 700 feet long, making a total length of 8,800 feet, or 1⅔ miles, and containing 150,000 cubic yards of material. The watershed is estimated to be 150 square miles. The creek is generally dry, but sometimes has a large flood volume passing down to Wichita River. The reservoir formed has a capacity of 13,000 acre-feet and covers 2,050 acres. It is estimated that it will irrigate from 4,000 to 8,000 acres. Part of this dam was washed away in May, 1901, but it is stated that it can easily be repaired.

LIMESTONE AND COMANCHE COUNTIES.

Stubenrauch system.—At Mexia, in Limestone County, J. Stubenrauch has been very successful in the use of a small irrigation plant for fruits and vegetables. The plant consists of a dam across a ravine, catching the storm waters and forming a tank covering about an acre of ground. From this the water is lifted to a height of 25 feet, by an 8-foot windmill, into an earthen reservoir 50 feet long and 100 feet wide. The reservoir is now being enlarged, to have double its present capacity. The total cost of the system was $300, including 700 feet of piping. Seven acres have been irrigated, but it is estimated that 15 acres could be watered. Mr. Stubenrauch has put in another system, with a reservoir covering an acre of ground, the dam having a height of 5 feet above the outlet pipe. For filling the reservoir he uses a 12-foot wheel. He pumps from a storage tank made by damming a ravine. The dam on top is fully 10 feet wide, and both the reservoir and the storage tank hold water like a jug. The total cost, including 600 feet of 2½-inch pipe for discharging water into the reservoir, was $485.

Mr. Stubenrauch says:

> For the gardener or fruit farmer there is no investment bringing in larger returns than an irrigation plant similar to what we have here. In the very driest season 300 bushels of sweet potatoes to the acre are easily grown, which can be disposed of during August and September at one's own prices. In 1899 there were grown some of the finest cauliflowers ever produced. Dozens of heads weighed over 6 pounds each. Have irrigated fruit only the past season (1900). Five acres irrigated as a truck farm near a good market are worth more to the owner than are 75 acres without, of similar land for the same purpose.

Lee system.—One and one-half miles from the town of Comanche W. T. Lee irrigates 5 acres from an 8-inch well 95 feet deep. The water is pumped by a windmill into a circular reservoir 100 feet in diameter and 6 feet deep. This reservoir was formed on a knoll, by scraping the earth from the central space into the leveed embankments. From the reservoir the water is conducted in different directions by 3-inch pipes and by ditches. The crops raised are chiefly garden vegetables and such fruits as pears, peaches, apricots, grapes, and blackberries.

WACO AND VICINITY.

In the suburbs of Waco, on both sides of Brazos River, pump irrigation has proved a paying investment. This is well established, not only by the data furnished, but by the fact that many are enlarging their plants and adding better machinery.

Plants east of Waco.—Two miles east of the city there is a cluster of a half dozen plants, all doing a successful business. E. Pordo has a surface well 19 feet deep and 6 feet in diameter, walled with brick. Ordinarily the water stands 3 feet in the well. A small centrifugal pump, having 2-inch discharge pipe, rests on the well covering and is operated by a 4-horsepower gas engine of local make. The head is 23 feet, into a flume 8 inches by 6 inches and 125 feet long, which empties into an earthen tank 60 feet by 60 feet on the inside. The system is reenforced by two Kirkwood windmills, which pump into elevated wooden tanks of 5,000 gallons capacity each. The windmills are 100 and 200 feet northeast of the tank, and each pumps out of a well of the same depth as the one just described. With good winds the windmills will supply sufficient water to irrigate the 3 acres. Adjoining the plant of Pordo is that of Robert Etheson, in all respects similar to that of the former. The plant of Charles Myers consists of a 4-horsepower Lambert gas engine operating a plunger pump. The well is 32 feet deep, and the lift from the water to the flume is 38 feet. The water is pumped into a wooden tank of 6,300 gallons capacity, from which it is distributed to the garden through four outlet pipes 1½ inches in diameter. Instead of conveying the water to the different sections of land by ditches, a system of 1½-inch pipes is used. The land is watered from the pipes by means of a hose, or simply by removing the cap of the hydrant. It costs 65 cents a day to operate the engine for twelve hours. The soil is black loam, slightly impregnated with sand. The plant was first used in 1894. Ten acres are irrigated, although double that amount could be irrigated by the engine and the auxiliary windmill. Near the plant of Mr. Myers, Fred Stalte irrigates 4 acres by the use of a small gasoline engine and a windmill.

Etheson system.—One mile north of the foregoing cluster of plants, near Brazos River, A. Etheson irrigates 12 acres by the use of a gas engine pumping from a surface well.

Dismukes system.—In East Waco Ed E. Dismukes irrigates 16 acres with a 6-horsepower gasoline engine and a cylinder pump. At present the water is pumped out of a 6-inch pipe driven into 12 feet of water. The well which formerly existed was filled up and the 6-inch pipe substituted for it. The pipe is screened to prevent clogging by the sand. The suction pipe is 2 inches in diameter and the lift 9 feet. The water is pumped into a tank 30 feet by 120 feet by 5 feet deep, from which it is distributed.

Faulkner system.—About 1½ miles north of Waco is the fruit farm and garden of C. Faulkner, a tract containing about 400 acres. Of this about 350 acres are planted in fruit (pears, peaches, Burbank plums, apples, and blackberries), and about 30 or 40 acres form a garden in which vegetables, strawberries, and market produce are grown. The garden tract and a portion of that containing fruit trees (the late fruits) are irrigated from reservoirs or tanks on the highest points of the field, the water being supplied by an artesian well. The tanks are five in number, and consist of four levees thrown up to form a rectangular or roughly circular basin in which the water rises to a sufficient height to be conducted by gravity through pipes and ditches to all parts of the field. One of the tanks covers about 4½ acres and has an average depth of water of 8 feet. Two of them are about 120 feet by 150 feet and average 6 feet depth of water; the remaining two are smaller. The well was sunk in 1898, is 1,850 feet deep, has a 16-inch casing for about 20 feet from the ground surface, and a 6-inch delivery pipe. The water has a temperature of about 100° F., and is under a good pressure. It leaves a slight white deposit on the ground irrigated—so slight that it appears more like white frost than anything else—which, it is said, does not in any way injure the vegetation. The water is conducted from the tanks in ditches (piped under the roads), and is distributed by side ditches and furrows. The average yield of pear trees is about 10 bushels, of peach trees about 5 bushels, and of Burbank plums (the only kind grown) 5 bushels. Apple trees have not yet begun to bear.

RICE IRRIGATION SYSTEMS.

GENERAL FEATURES.

The rice belt of Texas (fig. 18) extends from Sabine County, on Sabine River, to the Rio Grande, and at present includes two well-developed zones (the Beaumont and the Colorado Valley), which raise 75 per cent of the rice grown in the State, and several detached areas that are sure, with good management, to be the forerunners of extended systems in their respective localities.

In the Beaumont section the land is a level prairie, which heretofore has cut very little figure as an industrial factor. It is very flat, some of it having a slope of only 1 foot in 5,000 feet, and generally requires small levees and low lifts at the pumps. This flat section extends along the coast from Sabine River to the Rio Grande. The 250-foot contour above sea level is from 50 to 125 miles from the Gulf, while the strip 20 to 30 miles wide along the shore rises only a few feet above sea level.

In addition to this coastal belt the rice section has since 1897 been rapidly spreading back from the coast until it has reached Cuero, Fayetteville, and Hempstead on the west. In the flat sections the water is often obtained from bayous, and is frequently so impregnated with salt sea water that injury to the rice occurs. Rice must have an abundant supply of fresh water and a soil that is rich enough to nourish the plants and compact enough to hold the water, and it is being successfully grown in Texas wherever these factors are grouped, and where they do not exist naturally money and brains are grouping them with a twentieth-century effectiveness. No longer is the rice belt restricted to the old bayou country, but along the Brazos, the Colorado, the Guadalupe, and the Rio Grande more than 100 miles from the coast a high-grade rice is grown.

In addition, the irrigation of rice from wells will certainly prove of greater benefit to the Texas farmers than all of the big irrigation plants combined. The latter method of irrigation is in its infancy, but it is certain to become the chief factor in rice production in the State. The plant of George Vick, 2 miles east of Eagle Lake, is but the pioneer of many that will become established when the small farmer can, with a nominal outlay, convert his flat lands into a successful rice farm. A well 12 feet in diameter and 34 feet deep (7 feet of water), a traction engine to supply power, a submerged pump, an open box for a flume, a canal easily constructed—total cost $2,200—constitute Mr. Vick's equipment. With this 125 acres of excellent rice were raised in 1900. This plant is now owned by Hudson & Ayres, and is referred to later in these pages.

The rice land is laid off in sections or "cuts" so that the extreme difference in elevation will not exceed 6 inches. The size of the cuts varies with the character of the topography. A cut is surrounded by levees or dikes, to hold the water, and it may be that a hillock or hole

FIG. 18.—Map showing rice belt of Texas.

will occur in a cut. These can be ignored, however, for rice produces until time and the flow will level the one or fill the other. The water is pumped to the land by steam power, water power, or windmills, by far the greatest part of the work in Texas being done by steam.

From the best information obtainable in western Louisiana and eastern Texas it seems to be the consensus of opinion that it requires 9 gallons of water a minute for each acre of rice, or 1 second-foot to each 50 acres. In the Beaumont section the rainfall often reduces the pumping considerably. During 1900, a wet year, some pumps were operated only four days. But a dry season will require the pumps to furnish the entire 9 gallons a minute for each acre, and it is not good engineering to estimate on less than that quantity, which is equivalent to 12,960 gallons per twenty-four hours per acre. If x is the number of acres to be irrigated and y the lift in feet, the weight of water to be supplied each second is 1.25 x pounds, and the work done each second in pumping this amount is 1.25 xy foot-pounds. The theoretic horsepower required would therefore be $\frac{xy}{440}$.

Thus for $x = 1{,}000$ acres and for a lift of $y = 22$ feet an engine exerting 50 absolute horsepower would be required. The estimated

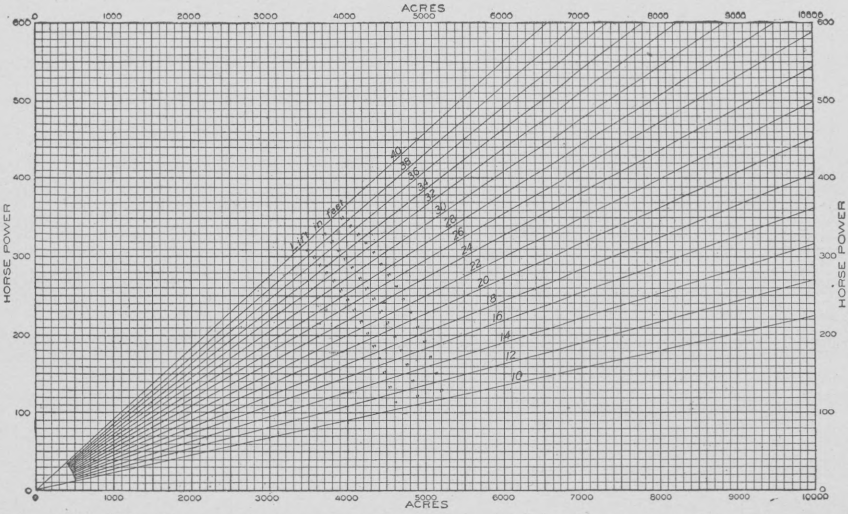


FIG. 19.—Diagram showing horsepower required for various lifts and acreages.

or claimed horsepowers of engines should be tested or reduced by a substantial fraction if disappointment in the capacity would be avoided.

By the aid of fig. 19 a person can at a glance determine the horsepower required to irrigate a tract of land. Given the lift and the number of acres to be irrigated, to find the horsepower of the engine first find the lift on the sloping lines (say 24 feet) and follow that line to the vertical line which corresponds with the number of acres to be irrigated (say 1,100), then follow the intersecting horizontal line to the left and read off the horsepower required—in this case 48—but in order to insure a safe margin an engine of 60 horsepower should be procured, and if the horsepower of the engine is based on the claims of agents a still larger margin should be allowed.

For some plants, owing to the contour of the ground, more than one lift is required, and more than one pumping station is necessary, the pumping capacity of each station being the same, but the machinery in one station being heavier than that in the others, depending on the lift.

By means of flumes the water is led from the pumps to the canals, and from the main canals is turned into the laterals from which it is distributed over the land. The main canals are usually very wide, being in most cases intended to act as reservoirs.

The first experiments with growing rice in Texas were in 1862, the farmers depending on the rainfall to furnish the water. But this trusting to Providence in the matter of rice cultivation did not pay, and to insure success pump irrigation was resorted to. The culture of rice by irrigation began about 1893. Prior to that time it had been grown in only a small way in ponds and marshes for home use. The method of growing rice on a large scale by irrigation and with improved machinery is comparatively new, and is peculiar to the Southwest. Unlike Georgia and the Carolinas, where rice is still grown in the old way, the rice being planted in rows, the field flooded, and the water drawn off several times during the growing season, in Texas rice is sowed on comparatively high land with drills or broadcast, is cut with self-binders, and is thrashed from the shock or stacked, to suit the convenience of the farmer. The same kind of machinery is used in raising, harvesting, and thrashing rice that is used with other small grain, the only difference in the cultivation being that rice lands are flooded after the rice is up to a height of from 3 to 6 inches. The water kills the grass and weeds and causes the rice to grow rapidly.

In from ten to twenty days (depending on the grower and the nature of the soil before harvest) the levees on the lower side are opened and the water is drawn off by means of the ditches made in throwing up the levees. For some plants this drainage requires more engineering skill in the arrangement of the levees than in making them fulfill all the requirements for feeding the land with water. In Texas the practice is to sow the rice any time from April 15 to June 15. It is kept flooded from ninety to one hundred and ten days, one hundred days being the average. From $1\frac{1}{4}$ to $1\frac{3}{4}$ bushels are sown to the acre. The land is plowed and harrowed and prepared as for wheat. The outfit or equipment varies with the acreage. After the rice is planted and the water is turned on eternal vigilance is necessary to keep canals and ditches in order, to prevent breaks and the consequent waste of water and drowning out of part of the crop. It is by no means an easy crop to manage. From the first flooding until harvesting the work is a muddy history of patience. Just before the crop ripens the water is drawn off to permit the ground to harden enough to bear the binder. If the rains set in at this critical time it entails additional expense and trouble to save the crop. In this respect the rice farmers away from the coast have an immense advantage, for there the rainfall aids during the flooding period and does not jeopardize the crop during the time of harvest. While the cost of pumping is more in the western part of the rice belt, the surety of an undamaged product will always overbalance the additional expense.

BEAUMONT SECTION.

The irrigation systems in the Beaumont section, which comprises the counties of Jefferson, Orange, Liberty, and Chambers, are shown in the maps forming figs. 20 and 21, and are described on the following pages.

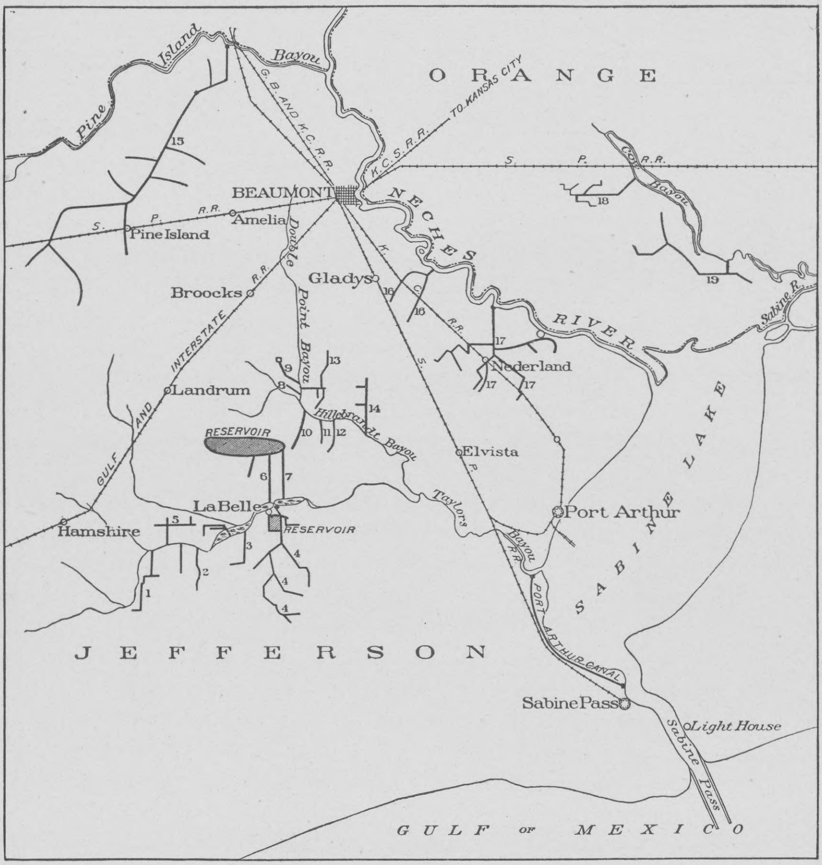


FIG. 20.—Map showing irrigation systems in the eastern half of the Beaumont section.

1. George Gill.
2. J. H. Garland.
3. J. C. Ward.
4. Jefferson County Rice Company.
5. J. H. Hoopes.
6. Lovell Brothers.
7. Ed. Moore.
8. Gulf Rice Growing Company.
9. Southern Rice and Trust Company.
10. C. A. Place.
11. Mr. Davis.
12. Schumacher & Fox.
13. Cameron & McClure.
14. Viterbo Brothers.
15. Beaumont Rice Company.
16. McFadden & Wiess Company.
17. Port Arthur Rice Company.
18. Des Moines Irrigation Company.
19. Cow Bayou Canal and Irrigation Company.

JEFFERSON COUNTY.

Of all the counties of Texas in which the people have tried rice growing by means of irrigation, Jefferson County undoubtedly stands first in extent of acreage and in successful cultivation.

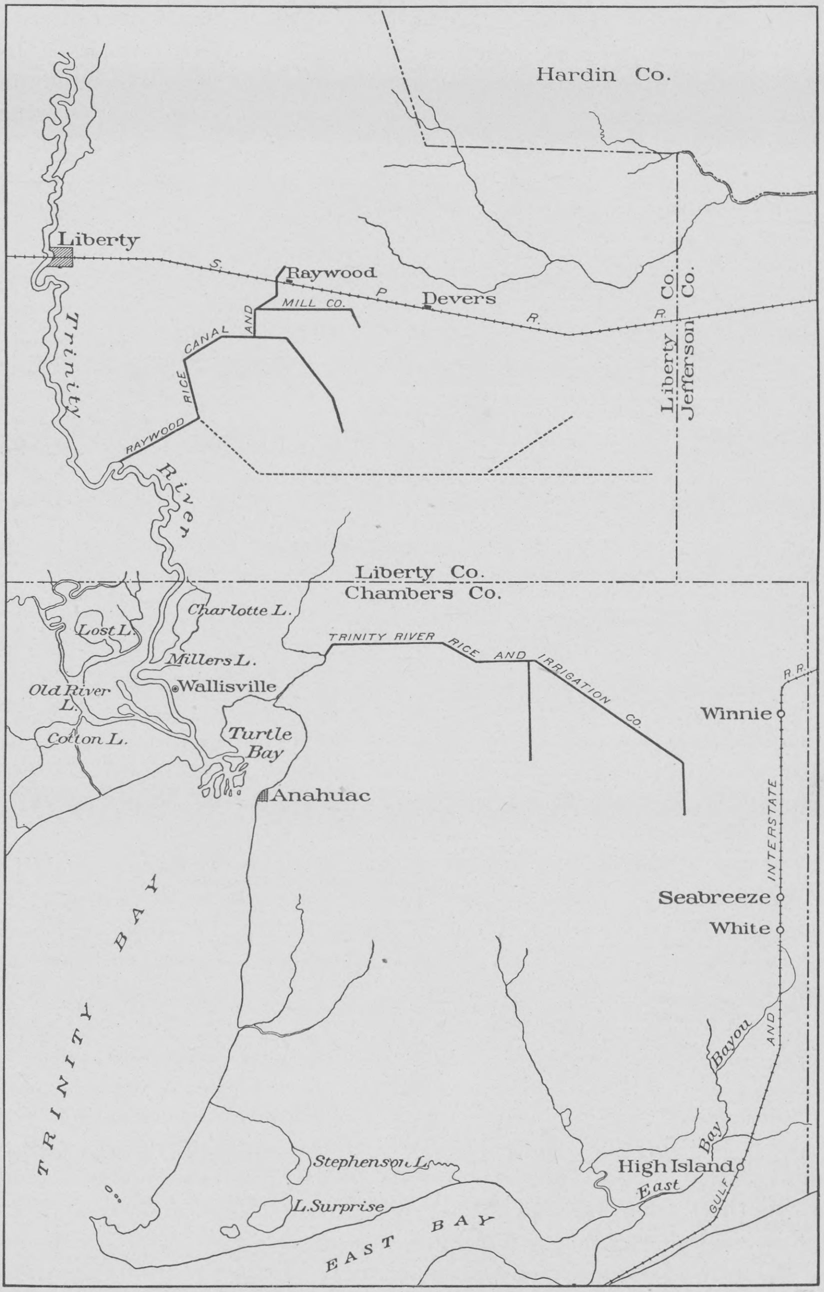


FIG. 21.—Map showing irrigation systems in the western half of the Beaumont section.

The rice farms and plantations are in two general districts, one in the valleys of Taylors and Hillebrandt bayous, above their junction in the southern part of the county, and the other along the valleys of Neches River and the Pine Island Bayou. All of the farms owned and operated by individuals are on Taylors and Hillebrandt bayous. There are also in the county five rice-growing companies, known as the Beaumont Rice Company, the McFadden & Wiess Company, the Port Arthur Rice Company, the Jefferson County Rice Company, the Southern Rice and Trust Company, and the Gulf Rice Growing Company.

The following is a list of the rice irrigators in the county. arranged in order going downstream:

Rice irrigators in Jefferson County.

Name.	Stream.	Acres irrigated.	
		1900.	1902.
George Gill	Taylors Bayou (S.)	600	1,500
J. G. Garland	do		750
J. C. Ward	do	900	700
Jefferson County Rice Co	do	1,800	2,300
J. H. Hoopes	Taylors Bayou (N.)		600
Bigham Bros	do	1,200	400
P. S. Lovell	do	850	760
Ed. Moore	do	100	60
Gulf Rice Growing Co	Hillebrandt Bayou (SW.)	150	300
C. A. Place	do	450	500
Southern Rice and Trust Co	Hillebrandt Bayou (NE.)	900	900
Cameron & McClure	do	550	680
Viterbo Bros	do	600	950
Beaumont Rice Co	Pine Island Bayou	12,000	15,000
McFadden & Wiess Co	Neches River	None.	9,000
Port Arthur Rice Co	do	4,000	8,500
	Wells		1,480
Total			44,380

General descriptions of the plants are given on the following pages; also, where obtainable, the opinions of the growers in reference to time of sowing, disposal of the straw, nature of the land, and other convictions drawn from experience.

The dry season of 1902 caused the impregnation of Taylors and Hillebrandt bayous with salt water, and the 10,000 acres of rice on these bayous suffered accordingly. It is claimed that the ship canal from Sabine Pass to Taylors Bayou has increased the danger from salt water in these bayous, and attention is here called to the necessity of a dam across Taylors Bayou at the mouth to keep back salt water.

TAYLORS BAYOU.

Gill system.—George Gill's farm is the westernmost irrigating from Taylors Bayou. The soil is of clay, with no sand, and is very hard to plow. Mr. Gill uses the drill and also sows broadcast, but he recommends the former method. His yield has averaged 7 sacks an acre. There are two complete pumping plants on the farm. One consists of an Ivens rotary pump, having a capacity of 9,000 gallons a minute against a lift of $12\frac{1}{2}$ feet, and a Skinner engine and 80-horsepower boiler made by the Columbia Boiler Works. The other plant consists of a Menge pump, having a capacity of 300,000 gallons an hour against a lift of 3 feet, and a Taylor compound engine and a boiler of the same make and steaming capacity as that of the other plant. The flume is 6 feet wide, 2 feet deep, and 24 feet long. The main canal is 60 feet wide and 3 miles long, with several laterals. The total cost of the equipment was about $5,000. Mr. Gill irrigated 400 acres in 1899, 600 acres in 1900, and 900 acres in 1901. For all purposes he recommends low-speed engines (though both of his engines are high speed) and slow-speed pumps, as they seem to give better satisfaction.

Garland system.—J. G. Garland's farm lies along Taylors Bayou, about 20 miles southwest of Beaumont. The soil is very sticky, although it works well when dry. Mr. Garland sows either with a drill or broadcast, from March 20 to about June 10, and uses the ordinary binder in reaping. While thrashing he saves sufficient straw for feeding purposes and burns the surplus. For the first rice sown irrigation is begun about May 20, depending on the season, and is continued until almost time of harvesting. The yield from this land has been 10 barrels to the acre, the price of seed from $3 to $5 a barrel.

He uses one pump, of the Menge pattern (manufactured by the estate of Joseph Menge at New Orleans, La.), having a capacity of 15,000 gallons a minute (33 second-feet) under a lift of 8 feet. A 75-horsepower Skinner engine drives the pump by means of rope transmission. The boiler used for steaming has a capacity of 90 horsepower, and was manufactured by the Union Iron Works and Skinner Engine Works, of Erie, Pa. There are two laterals—one a half mile long and the other three-fourths of a mile long. The total cost of the plant was about $2,700. With this equipment Mr. Garland irrigated 600 acres in 1899 and 750 acres in 1902.

Ward system.—The farm of J. C. Ward is the next one on the south side of Taylors Bayou. The soil is generally sandy, with a good clay foundation near the surface of the ground. His methods of sowing, cultivating, and reaping are as follows: Beginning about March 1, he continues to sow until the last of May, using either the drill or sowing broadcast. Irrigation is begun about the 1st of June, though this depends upon the weather. When matured, the rice is harvested with binders, and then thrashed. All the straw needed for feeding purposes is saved, the remainder is usually burned. The average yield has been 10 barrels (35 bushels) an acre, for which Mr. Ward has received $3 a barrel. There are two complete pumping plants on the farm. The pump at the larger station is of the Menge type, with a capacity of 720,000 gallons an hour (27 second-feet). A 100-horsepower Atlas engine is installed, with only an 80-horsepower Atlas boiler. At the other plant there is a 500,000-gallon Menge pump, an engine of local make, and only a 30-horsepower boiler. The lift in each case is 9 feet. The larger plant cost $5,000, the smaller only $1,500. The flume is 60 feet long, 12 feet wide, and 4 feet deep; the box part is constructed of 2-inch planking. The main canal is from 60 to 40 feet wide and 2 miles long, and has several large laterals

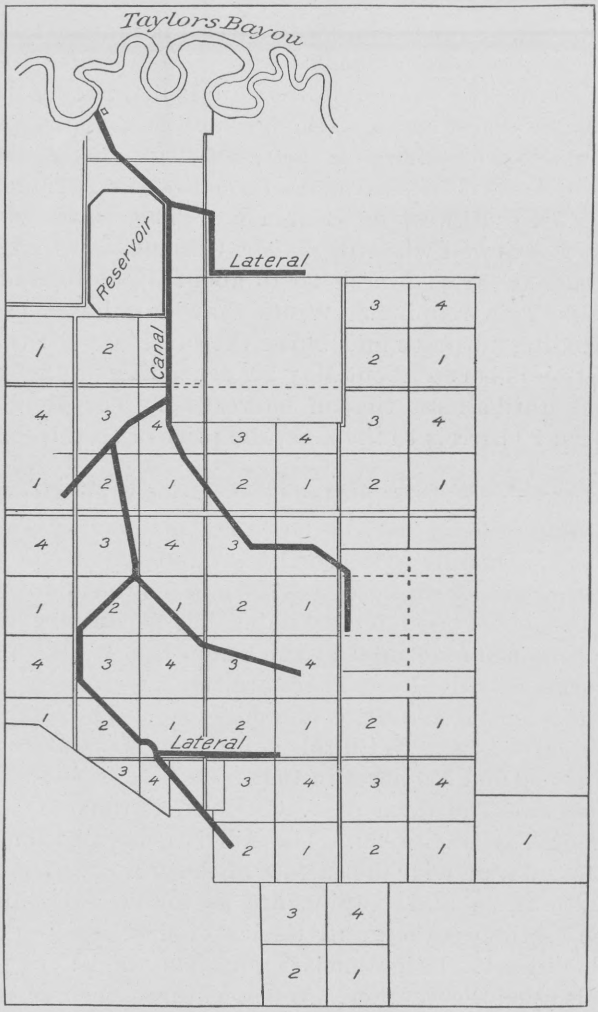
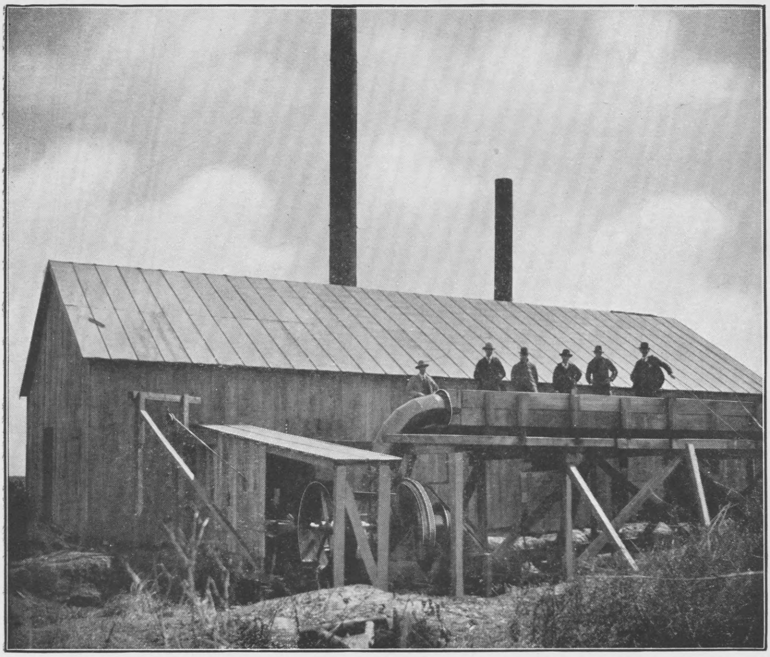


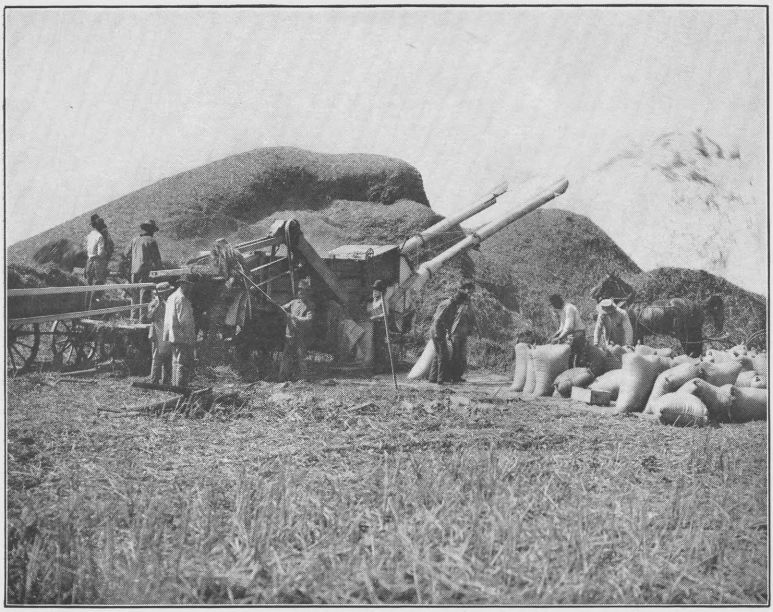
FIG. 22.—Map of Jefferson County Rice Company's farm, showing irrigation canals.

branching off. Mr. Ward irrigated about 400 acres in 1899 and 900 acres in 1900, but the plant is now leased to Bigham Brothers.

Jefferson County Rice Company system.—The farm of the Jefferson County Rice Company is 17 miles from Beaumont, and is the last one on the south side of Taylors Bayou, all the land below being marshy and subject to overflow from salt water. Two pumps, one 22-inch Marri and one 15-inch Ivens, of capacities of 20,000 and 7,500



A. PUMPING STATION OF JEFFERSON COUNTY RICE COMPANY.



B. RICE THRESHER AT WORK ON PORT ARTHUR IRRIGATION COMPANY'S PLANTATION.

gallons a minute, respectively, raise the water from the bayou against a lift of 15.1 feet. The engines are of the Erie make, of capacities of 150 and 50 horsepower, respectively. The boiler is of the same make, and has a steaming capacity of 200 horsepower. The flume is 12 feet wide, 3 feet deep, and 180 feet long, and discharges into a canal 100 feet wide. The soil is a deep, black, sandy loam and has a clay subsoil. In 1899 it yielded 8 sacks to the acre. This farm has been irrigated six years. Fourteen hundred acres were planted in 1899, but the number was reduced to about 800 acres in 1900. In 1901 about 3,000 acres were irrigated. Pl. VII, *A*, is a view of the pumping station. The smaller pump was installed in 1896, the larger (a 150-horsepower) in 1898. The company owns 10,424 acres of land, which they have divided into quarter sections and thrown open to actual settlers. So far 3,800 acres have been sold to settlers, on the crop-payment plan, at from $20 to $25 an acre, one-half of the crop being given to the company until the land is paid for. The highest point on the farm is at the pumping station, and this enables the company to flood the whole tract without additional lifts by pumping. To insure a full supply, a reservoir covering 500 acres has been constructed, with an average depth of 4 feet and a capacity of 2,000 acre-feet, or 1,300,000 gallons. A map of this farm showing the irrigation canals is shown in fig. 22.

Hoopes system.—J. H. Hoopes's farm is in the lowlands made by Taylors and Hillebrandt bayous. Some of the soil is black and waxy, some is black loam, and some is sandy, but all has a clay subsoil. The yield has been from 8 to 12 sacks to the acre. A Menge pump, manufactured in New Orleans, with a capacity of 16,600 gallons a minute, furnishes the water. The pump works against an average lift of 10 feet, varying with the stage of the water. An Erie engine of 60 horsepower is used, and an Erie boiler of the same steaming capacity. The flume is 32 feet long, 9 feet wide, and 1 foot deep, constructed of 1-inch boards and lined with galvanized iron, which is an exception to the ordinary flume in this district. The main canal is 100 feet wide and 1 mile in length. Six hundred acres were planted in 1899, 400 acres in 1900, and 600 acres in 1902. The total cost of the plant was about $4,000.

Moore system.—Mr. Ed. Moore's farm is near the Hoopes farm. The soil is a mixture of clay and loam. The yield last year was below the average, being only from 6 to 8 sacks to the acre. He uses an Ivens centrifugal pump having a capacity of 200,000 gallons an hour against a lift of 17 feet. One 60-horsepower engine, of the Cleveland make, operates it, steam being supplied by a 75-horsepower boiler. The flume is 200 feet long, 3 feet wide, and 1 foot deep. The canal is from 15 to 30 feet wide and 2 miles in length. One hundred and fifty acres were irrigated in 1899, 100 acres in 1900, and 60 acres in 1902.

Bigham system.—The plant of Bigham Brothers is on the north side of Taylors Bayou, near Labelle. It consists of two pumps having discharge penstock 2 by 3 feet. The lift of one pump is 8 feet, of the other pump 12 feet. The power is supplied by two engines of 40 and 80 horsepower, respectively. The water is raised into flumes 30 and 100 feet long, and these discharge into the main canals, which are a half mile and 3 miles long, respectively. There were 400 acres in rice in 1899, 1,200 acres in 1900, and 1,200 acres in 1901, notwithstanding the unusual severity of the latter season. The yield in 1900 was 8,000 sacks, commanding $3 a sack. The soil is a black loam, and is well suited to rice culture. This firm operates the J. C. Ward farm.

Lovell system.—The plant of the Lovell Brothers (Willard G. Lovell, manager) is on the north banks of Taylors Bayou. It consists of an Ivens pump having a 21-inch suction pipe and an 18-inch discharge pipe, and estimated to have a capacity of 18,000 gallons a minute (40 second-feet) under a maximum lift of 18 feet. The plant is run by a Houston, Stanwood & Gamble engine of 100 horsepower. With an engine efficiency of 75 per cent this can pump only 275 gallons a second, or 16,500 gallons a minute. The flume is 146 feet long, 10 feet wide, and 3 feet deep. The length of the main canal is 3½ miles, the width 50 feet. One mile of the laterals is 20 feet wide, 1½ miles are 15 feet wide, and a half mile of them is 10 feet wide. In 1899, 1,100 acres of rice were sown; in 1900, 850 acres; in 1901, 850 acres; and in 1902, 760 acres.

HILLEBRANDT BAYOU.

Southern Rice Company system.—The plant of the Southern Rice Company is the northernmost diverting water from Hillebrandt Bayou. It is about 12 miles south of Beaumont. The plant is equipped with Ivens pumps having 22-inch suction pipes and 21-inch discharge pipes, operated by a 100-horsepower Chandler & Taylor engine, estimated to have a capacity of 15,000 gallons a minute (33 second-feet) under a lift of 13 feet. With an engine efficiency of 70 per cent, 71 horsepower will do this work. The water is delivered by the pumps into a flume 150 feet long, 8½ feet wide, and 4 feet deep. The main canal is 1½ miles long and 75 feet wide, and delivers into laterals 12 feet wide. The soil is black, with a clay subsoil. Water was rented in 1899, when 200 acres of rice were sown, yielding 2,000 sacks, which sold for $2.70 a barrel. The amount sowed in 1900 was 900 acres, yielding 7,000 sacks, which sold for $3 a barrel. In 1902 about 960 acres were sown.

Gulf Rice Growing Company system.—The farm of the Gulf Rice Growing Company is 10 miles southwest of Beaumont on Hillebrandt Bayou. The lift is about 12 feet, and the water is pumped by a 90-horsepower engine. The soil is a clay loam, 300 acres of which, in rice, were irrigated in 1902.

Place system.—The plant of C. A. Place has one Morris pump having 15-inch suction and 12-inch discharge, operated by a 25-horsepower Westinghouse "Junior" engine, having a maximum capacity of 10,000 gallons a minute (222 second-feet) against a lift of 12½ feet. The water is delivered into a flume 28 feet long, 4 feet wide, and 2 feet deep, which in turn delivers it into the canal, which is 1 mile long and 60 feet wide. The soil is clay and black loam, with a subsoil. Two hundred and fifty acres, in rice, were irrigated in 1899, 450 acres in 1900, and between 450 and 500 acres in 1901. The yield in 1900 was 3,400 sacks, commanding $3 a sack. The plant cost $2,500. Previous to 1899 other parties owning this farm had irrigated 125 acres.

Cameron & McClure system.—The rice plantation belonging to Messrs. Cameron & McClure is on both sides of Hillebrandt Bayou. The soil is light, but it has a fine clay subsoil which retains the water well. The rice is sown from March 25 to May 1, and if the season is not rainy irrigation is begun when the rice is about 6 inches high. The yield has been from 7 to 10 sacks to the acre, and the price received ranges from $1.25 to $3.40. The lower prices were received for rice of poor quality, much of it being damaged by what is termed "red rice." The reaping is done with the ordinary harvester and binder. The owners of the plantation have found that the straw makes very good hay.

Owing to the farm being on both sides of the bayou, there are two complete pumping plants. At one of the plants there is in use a 6-foot Menge pump, having a capacity of 12,000 gallons a minute (27 second-feet) against a head of 10½ feet. The engine is of the Skinner type, of a capacity of 75 horsepower, and receives steam from a 100-horsepower boiler. The other plant has a 12-inch pump of the Van Wie make, which has a capacity of 7,500 gallons a minute (17 second-feet) against a head of 10½ feet. This pump is run by a 40-horsepower Skinner engine which is supplied with steam by a 50-horsepower Van Wie boiler.

The flumes are 40 and 60 feet in length, 12 and 8 feet wide, and 12 inches deep. They are constructed of 4-inch by 4-inch timber in the bents, while the sides and bottoms are made of 12-inch planking.

Four hundred and fifty acres were irrigated during the year 1899, 550 acres in 1900, and 680 acres in 1902.

Viterbo Brothers system.—This system is 12 or 14 miles southwest of Beaumont. One Menge pump, costing $500 and having a capacity of 25,000 gallons a minute against a lift of 7 feet, is used. Two boilers, each of 50 horsepower, furnish the steam to a 75-horsepower engine. The canal is 40 feet wide and 2½ miles in length. A reservoir, covering an area of 225 acres and having a depth of 6 feet, holds the storage water. There are 1,000 acres leveed in, but not all of this is planted in rice. The yield on this land has been from 7 to 18 sacks to the acre. Six hundred acres were sown in 1899, 600 acres in 1900, 700 acres in 1901, and 950 acres in 1902.

PINE ISLAND BAYOU.

Beaumont Irrigation Company system.—This company has been operating the largest rice plantation in Texas. It is in the northern part of Jefferson County, lying along the south side of the Pine Island Bayou. There are two lifts. The first one is at the crossing of the

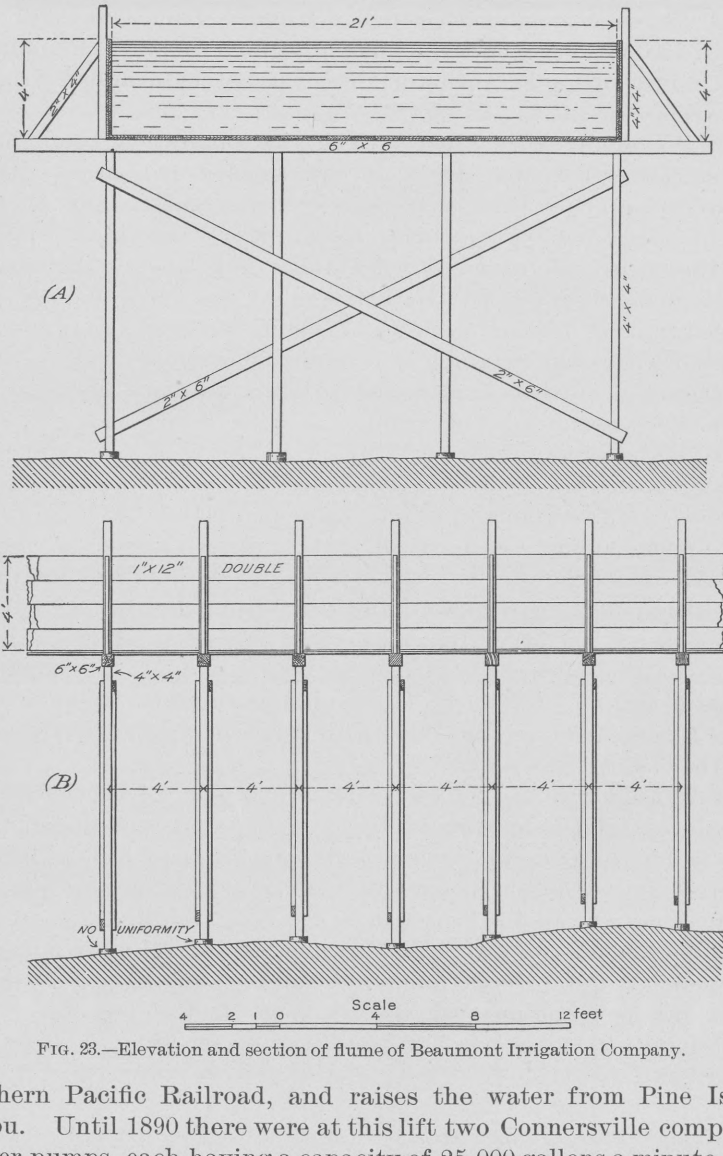


FIG. 23.—Elevation and section of flume of Beaumont Irrigation Company.

Southern Pacific Railroad, and raises the water from Pine Island Bayou. Until 1890 there were at this lift two Connersville compound blower pumps, each having a capacity of 25,000 gallons a minute. To each of these pumps was attached one Hamilton-Corliss engine of 250 horsepower, steam being supplied by 300-horsepower boilers. In 1900 another pump of the same capacity was installed, with a corresponding engine and boiler. The pumps work against a lift of 31 feet, and have always given satisfaction. They are 15 feet above the water in the bayou, and force the water 16 feet into the flume. Wood is used altogether for fuel. The flume, shown in elevation and section in fig. 23, is 4 feet deep, 21 feet wide, 1,500 feet long, and has a total fall of only 4 inches. The box part is constructed of 1-inch by 12-inch planks, the floor and sides being double planked, and all joints broken and tarred. The floor rests on 6-inch by 6-inch sills, which are supported by four 6-inch by 6-inch uprights. The distance between the bents is 4 feet. The canal is 150 feet wide.

For 3 or 4 miles from this lift the land is covered with pine growth and is somewhat broken. The portion covered with timber would be expensive to prepare for cultivation, and that broken could not be irrigated. So the water has to be carried to almost the second lift before the farms are reached. The whole plantation is on the prairie, the land gradually rising from the first lift. It is about 5 miles from the first lift to the second lift, where the water is raised 11 feet. The pumps here, both the two old ones and the new one, have the same capacity and are of the same make as those at the first plant, but owing to the low lift they are of lighter construction. The engines also are of the same make, and are of 150 horsepower each. The same may be said of the boilers, the steaming capacity of which is 200 horsepower. The flume is similar to the one at the first plant, but it is only about 200 feet long.

It is estimated that about $135,000 has been expended on this plantation. The company irrigated about 5,000 acres in 1899, a large part of which was rented to individuals. In 1900 12,000 acres were irrigated, 4,000 of which were cultivated by the company, the remainder being rented to 37 individuals. The custom of renting is to charge 2 sacks (162 pounds) an acre for water alone and 2 additional sacks where the company rents the land, making a total of 4 sacks an acre where both land and water are rented. The average yield on this plantation is about 10 sacks to the acre, though some of the tracts may run up as high as 20 sacks. The canals and laterals follow the general contour of the ground. Machinery has been added from time to time, till now (1902) the river plant has three 350-horsepower and two 250-horsepower engines and two 36-inch and two 48-inch Connersville and one 60-inch Roots pumps, while at the second lift there are two 200-horsepower and two 125-horsepower engines and two 36-inch Connersville and two 36-inch Morris pumps. In 1902 there were irrigated 14,615 acres.

NECHES RIVER.

Port Arthur Irrigation Company system.—This plantation is on Neches River, about 12 miles southeast of Beaumont and about the same distance northwest of Port Arthur. The pumping plant is on the banks of the river, from which the water is pumped, the lift being

21 feet. The plant has been in operation three years. Until the season of 1900 there was in use only one 18-inch Ivens pump, having a capacity of 18,000 gallons a minute. In 1900, however, two 24-inch Ivens pumps, each having a capacity of 24,000 gallons a minute, were installed. The other operating machinery, including that installed with the new pumps, consists of two 125-horsepower boilers, four 100-horsepower boilers, one Chandler & Taylor engine, and one new Corliss engine of 350 horsepower.

The flume was formerly about 100 feet long, 20 feet wide, and 4 feet deep, but in 1900 this was increased in width to about 60 feet. The main canal is 100 feet wide and has very high levees, but it is doubtful whether this is the most economical form of construction. One thousand seven hundred acres were irrigated in 1899, 4,000 acres in 1900, and 7,000 acres in 1901. A charge of 2 sacks is made for water and 2 sacks for land rented. Pl. VII, *B*, is a view of a rice thresher at work on this farm. The yield in 1899 was about 14 sacks an acre. The rice grows very rank, varying in height from 5 to 7 feet. Some of the straw was baled and found to make very good hay; the remainder was burned. All of the land on which this rice is grown is black and sticky. (See map, fig. 20, for plot of the main canal and laterals.) This company irrigated 8,500 acres in 1902.

McFadden & Wiess system.—This plant is on the western bank of Neches River, or rather on the edge of the marsh that lies between the river and the rice lands, about 7 miles southeast of Beaumont. The water is conveyed from the river to the plant by a canal dredged out of the marsh. Its length is 2,000 feet, width 40 feet, and depth 6 feet. The plant was located on the edge of the marsh, a foundation being obtained by driving piles 3 feet apart under the power and pump house. On top of the piles several courses of grillage work were laid, and this was capped by a cement foundation for the machinery.

There are two Connersville rotary cycloidal pumps, with suction pipes 2½ by 6 feet and discharge pipes 4 feet in diameter. The pumps are run by two Hamilton-Corliss compound condensing engines of 250 horsepower each. The capacity of the plant is estimated at 70,000 gallons a minute (156 second-feet) under the lift of 22 feet, which would require an efficiency of 78 per cent in the machinery. The main canal is 6 miles long, 100 feet wide, and 2½ feet deep. The plant cost $65,000, the machinery costing $40,000. Four thousand acres of rice were irrigated in 1901, and 9,000 acres in 1902.

WELLS.

In addition to the canal plants in Jefferson County there are a number of plants that derive their water from wells. These are located near Hamshire and China. The well of George J. McManus, near Hamshire, will serve as a type of those in this section. There are two wells 40 feet apart, connected in the pit 22 feet deep. One is

81 feet deep; the other 180 feet. The water-bearing sand was found to be 72 feet thick, and the screw was put in in three lengths of 20 feet each. It consisted of an 8-inch pipe with three-fourths inch holes bored with $1\frac{1}{4}$-inch clear space between them. The pipe was then wrapped with No. 16 wire, one-fifth of an inch apart, and on this was wrapped the copper gauze of mesh 60, 30, and 40 to an inch. The 6-inch Van Wie pump is operated by a 22-horsepower Gear-Scott steam engine, using Beaumont oil for fuel. From this plant 120 acres of rice were irrigated in 1902. In the same neighborhood H. C. Wheeler has a well plant that derives its water from flowing wells. At one of these wells it was 207 feet to the water-bearing sand that furnishes the supply. This is 43 feet in thickness, making the total depth of this well 250 feet. Near Hamshire the acreage from wells was: McManus, 120; Wheeler, 300; Heisig, 185; total, 605 acres.

The acreage around China from well plants was, Hal Aldridge, 125; J. W. Kirby, 200; Burrows, 200; Southwestern Company, 200; Spivy, 150; total, 875.

ORANGE COUNTY.

COW BAYOU.

Cow Bayou Canal and Irrigation Company system.—Rice irrigation has been conducted in Orange County for about ten years. In 1891 F. H. Catron installed a 50-horsepower engine to operate a Menge pump under a head of 8 feet, the plant being located on Cow Bayou, about 6 miles southwest of the town of Orange. The ditch was 1 mile long and 20 feet wide. The plant cost $6,500, the canals and laterals costing $5,000 and the engine and pumps $1,500. The capacity of this plant was 5,000 gallons a minute, or 11.11 second-feet. With an efficiency of 75 per cent for the engine the pumping of this amount of water requires only 14 horsepower. Six hundred acres of rice were irrigated in 1896. This system has passed into the control of the Cow Bayou Canal and Irrigation Company, which has remodeled the whole plant, removing the pump to a more advantageous location and installing one 250-horsepower Viker-Corliss engine having an 18-inch by 36-inch cylinder and operating two 18-inch Ivens double-suction latest improved pumps having a capacity of 30,000 gallons a minute (66.67 second-feet) against a lift of 14 feet. There are $5\frac{1}{2}$ miles of main canal. (See fig. 20.) For the first 1.5 miles the width is 80 feet, for the next 1.5 miles it is 50 feet, and for the remainder of the distance it is 60 feet. The water is first pumped into a flume 20 feet wide, 4 feet deep, and 300 feet long. The cost of the plant, including engines, pumps, canals, laterals, flumes, etc., was $25,000. Three thousand acres were planted in rice in 1901.

Des Moines Rice Company system.—About 7 miles west of Orange and 4 miles from Terry is the plant of the Des Moines Rice Company, which consists of an Ivens pump having 21-inch discharge pipe, operated by a 125-horsepower Atlas engine, having a claimed capacity of 20,000 gallons a minute (44 second-feet) against the lift of 17 feet. This duty will require an efficiency of 68 per cent in the engine. Pine wood is used as fuel, and it takes about 5 cords each twelve hours. The flume is 200 feet long and 10 feet wide. The main canal is 3½ miles long and 100 feet wide, and there are 4 miles of branches varying in width from 20 to 50 feet. (See fig. 20.) The plant was installed in 1899, and 960 acres of rice were sowed that year, commanding a price of $3.25 a barrel of 162 pounds. In 1900, 1,400 acres were planted, and in 1901 about 1,600 acres. The soil is a black loam.

ADAMS BAYOU.

Orange County Rice Company system.—The plant of this company is on Adams Bayou, 4 miles from Orange. It consists of a 24-inch Ivens direct-connected pump and a 100-horsepower engine. Under a lift of 8 feet the plant has a capacity of 20,000 gallons a minute. In 1901 about 2,500 acres were irrigated, and 3,500 acres in 1902. The first lift is 16 feet, and the two pumping plants, 2 miles apart, when visited in August, 1902, had all the rice well watered, and the whole crop was healthy in appearance.

Clark system.—The Clark Canal Company (A. T. Chenault, manager) is north of Orange and takes its water from the east side of Adams Bayou, under a lift of 16 feet. The machinery consists of a 50-horsepower Morris steam pump, and 500 acres were planted in 1902.

Giles system.—The plant of Giles Brothers takes its water from Adams Bayou, on the west side, under a lift of 18½ feet. One 50-horsepower Ames engine operates the Menge pump, with a 4 by 4 penstock. In 1902 550 acres were planted.

Acreage in Orange County.—The acreage in Orange County is as follows: Cow Bayou Company, 4,500; Orange County Company, 3,500; Des Moines Company, 1,200; Samuel Wilson Company, 600; Clark Canal Company, 500; Giles Brothers, 550; total, 10,850 acres.

CHAMBERS COUNTY.

TURTLE BAYOU.

The Trinity River Rice and Irrigation Company take their water from Turtle Bayou and Trinity River, 22 miles south of Liberty. (See fig. 21.) The plant consists of four large pumps, having 24-inch suction and discharge pipes, and a capacity of 20,000 gallons a minute each, or a total of 80,000 gallons a minute (173 second-feet), against a lift of 32 feet. There are four 250-horsepower engines, exerting a total of 1,000 horsepower (estimated). However, with an efficiency of 70 per cent it requires only 781 horsepower to pump the estimated quantity. Three of the pumps should be able to do all of the work. There are three flumes of a total length of 2,400 feet, a width of 15 feet, and a depth of 40 inches and 16 miles of main canals 100 feet wide and 10 miles of laterals 40 feet wide. The plant cost $13,000, and in a dry season can irrigate 9,600 acres of rice with the usual evaporation. In 1900, 6,000 acres of "Providence" rice were cultivated, producing 29,000 sacks, which brought $3 a barrel. A sack averages about 180 pounds, while a barrel is always 162 pounds. The company sowed 9,000 acres in 1902. Generally they sow during May and June, using about 60 pounds to the acre. Renters are charged one-fifth of the crop for water, one-fifth for land, and one-tenth for seed—i. e., the company furnishes land, seed, and water, and receives half of the crop.

LIBERTY COUNTY.

TRINITY RIVER.

The Raywood Rice Canal and Milling Company has one of the largest plants in Texas. It is on the east side of Trinity River in Liberty County (see fig. 21), and cost $200,000. It was not installed until the latter part of 1900, but owing to excessive rains the company raised a good average crop of "Providence" rice that year. There are 10 miles of main canal from 100 to 150 feet wide, and 25 miles of main laterals from 60 to 80 feet wide. There are three lifts aggregating 70 feet, with a pumping station at each lift. The pumps are of the Root rotary pattern. Those at the river station have an estimated capacity of 45,000 gallons a minute (100 second-feet) under 16 feet lift. The suction pipes are 3 by 8 feet. Four of the pumps have circular discharge pipes 5 feet in diameter; the other two have rectangular discharges 3 by 8 feet. The pumps at the river station are operated by two 475-horsepower Lane & Bodley engines. The second station is equipped with two 375-horsepower engines operating two Root rotary pumps under a lift of 24 feet. The third station has two 250-horsepower engines operating two pumps having 5-foot circular discharge and suction pipes. The head at the latter station is 30 feet.

The soil is a black loam. Six thousand acres were cultivated in 1900, producing 50,000 sacks, which sold for $3.25 a sack. In 1902 the company planted 15,000 acres. The rice is sowed by a drill or broadcasted in April, May, and June, $1\frac{1}{3}$ bushels to the acre. The land is let out to renters on the one-half plan—i. e., one-fifth of the crop for land, one-fifth for water, and one-tenth for seed. In 1901 oil was used for fuel, the cost being about one-third that of coal.

WELLS.

Near Stilson, 32 miles east of Houston, on the Southern Pacific Railroad, Brown & Son have a rice plant, the water for which is obtained from an artesian well 405 feet deep. The pit is 17 feet deep. The first 280 feet are of $8\frac{1}{4}$-inch casing, the remainder of $5\frac{5}{8}$-inch casing. A 22-horsepower Port Huron traction engine supplies the power required to operate the 6-inch Morris pump, which raises the water 12 feet into a flume. The land is composed of a black prairie soil. One hundred and sixteen acres were irrigated in 1901, producing 870 sacks of rice. In 1902 200 acres were planted.

N. B. Sapp has an 8-inch artesian well 380 feet deep. In boring this well a cypress log was struck at a depth of 360 feet. The operating machinery consists of one 18-horsepower Foos gasoline engine and two 16-inch Morris submerged pumps working under a lift of 8 feet. Water was not procured in time for the 1901 crop.

The well at the plant of the Hill-Brown Rice Land and Irrigation Company (C. A. Brown, manager) is an 8-inch, 485 feet deep, the water rising to within 10 feet of the surface. The machinery consists of a Morris direct-connected engine 8 by 8 inches and two 8-inch Morris pumps, the steam being supplied by two 30-horsepower Erie City boilers. The season of 1901 was so dry that no rice was planted. Additions have been made to the plant of this company, and in 1902 the crop was expanded to 1,000 acres.

HARRIS COUNTY.

Harris County systems.—Nearly 90 wells in Harris County are furnishing water for rice irrigation, over half of these being located in the vicinity of Clodine. The following is a list of the plants in this county: Sheldon canal, 2,000 acres; Harris Rice Company, 600 acres; F. B. West, 150 acres; J. E. Ross, 80 acres; A. W. Wilkerson, 250 acres; W. H. Myers, 75 acres; Conrad Bering, 125 acres; C. L. & C. H. Bering, 200 acres; Baldwin H. Rice, 280 acres; Meadow Brook Company, 3,600 acres; S. P. Dickey, 640 acres; F. E. Markeley, 60 acres; J. H. O'Donnell, 650 acres; J. E. Cabaniss, 75 acres; A. Stockdick, 40 acres; E. Couthwaite, 65 acres; plants at Stella, 75 acres; T. J. Roberts, 60 acres; Mrs. Ida W. Baker, 75 acres; total, 9,100 acres.

Sheldon system.—Two and one-half miles from Sheldon, 16 miles east of Houston, the Sheldon Canal Company takes the water for its 2,000 acres of rice this season from the San Jacinto River against a 40-foot lift. The plant consists of one 300-horsepower Corliss engine and one 18-inch Van Wie centrifugal pump. The water is delivered into a flume 226 feet long, which in turn delivers it into the canal, which is 120 feet wide and 4 miles long. The land commanded by the canal lies on both sides of the Southern Pacific Railroad.

O'Donnell system.—Thirteen miles south of Houston, near Erin, on the Santa Fe, J. H. O'Donnell has six wells, 50 feet apart. These are all under 98 feet in depth and have 46 feet of water-bearing sand and gravel; the whole length in sand is screened, and the water rises in the well to within 4 feet of the surface. The power is supplied by four 28-horsepower Fairbanks gasoline engines, which operate the 5-inch Morris pumps. These are placed in pits 15 to 17 feet deep, and are operated in batteries of three each. The soil is black hog wallow, and 650 acres were irrigated during the season of 1902.

Meadow Brook system.—On the Meadow Brook farm, northeast of Clodine, Fort B. Smith has drilled forty-seven wells and has twelve complete plants, ten operated by steam and two by Fairbanks gasoline engines. A complete plant consists of a central steam boiler, using oil for fuel, and two or three engines, located in either opposite directions from the boiler or in such position as to form a right angle with the central plant. Thus one of these plants consists of a 125-horsepower Erie City boiler operating two 35-horsepower engines, which run the centrifugal pumps. Two wells are connected by piping in each pit, and one pump is then connected to the common junction. These companion wells are about 20 feet apart and are usually 150 deep and 10-inch bore.

Dickey systems.—Sixteen miles west of Houston and 1½ miles north of Daisy, S. P. Dickey has a rice farm where 640 acres were irrigated this season from five wells. These wells are of an average depth of 200 feet, and the power to raise the water is supplied by four 16-horsepower Fairbanks-Morse gasoline engines and one 25-horsepower steam engine. South and southwest of Clodine, in Fort Bend County, are located the well plants of B. A. Evarts, with 125 acres; H. F. Ring, with 165 acres, and F. E. Jones and S. M. Gordon, with 500 acres. The wells are usually 110 and 250 feet deep, connected in the same pit by a T joint.

Seven miles northwest of Houston C. L. and C. H. Bering have a rice farm on the Buffalo Bayou, from which water is taken. The lift is 50 feet. The soil is a black hog wallow. One hundred and fifty acres were irrigated in 1901, commanding from $3 to $3.75 a sack. The plant consists of one 10-inch Hooker duplex steam pump and a 60-horsepower boiler, the capacity being estimated at from 1,500 to 1,800 gallons a minute. In 1902 200 acres were irrigated.

Near the plant just described Conrad Bering had 87 acres in rice in 1901, which he irrigated from three wells, 400, 450, and 500 feet deep, and all being flowing wells the lift is very slight. The wells cost $1,500 each. The 8-inch Knowles duplex pump is on the surface. The yield was 17 sacks to the acre, selling for from $2.75 to $3.50 a sack. In 1902 125 acres were irrigated.

Eighteen miles east of Houston, on Bear Bayou, the Harris County Rice Company (Radford & Co.) had 110 acres of rice in 1901, yielding 1,040 sacks, commanding $3.40 a sack. Their engine is a 125-horsepower Watertown high-speed engine, and their pump a 15-inch Lawrence. The lift is 42½ feet, and the estimated capacity 7,000 gallons a minute. The main canal is 40 feet wide and 1.6 miles long. During the season of 1902 600 acres were irrigated.

Systems near Katy.—In the vicinity of Katy Messrs. J. E. Cabaniss, A. Stockdick, W. J. Nelson, William Eule, and T. G. Roberts have well plants ranging in capacity from 40 to 90 acres for this year. The wells are from 93 to 130 feet total depth and have screens from 12 to 20 feet long. Cabaniss and Eule use Foos gasoline engines of 22 and 14 horsepower, respectively; Stockdick uses a 22-horsepower Fairbanks-Morse, while Nelson and Roberts use steam engines. The Morris pumps are used by Cabaniss, Eule, and Roberts, while Eule has a Van Wie and Stockdick a Ganed. The acreage is as follows: Cabaniss, 75; Stockdick, 40; Nelson, 90; Eule, 50; Roberts, 60.

Three miles from Genoa, on the Galveston, Houston and Henderson Railroad, A. W. Wilkerson has an irrigation plant consisting of two stations about a half mile apart. At one station there is a 22-horsepower portable engine and an 8-inch Morris pump; and at the other station a 7-horsepower Foos gasoline engine running a 6-inch Morris pump. The water is obtained from $8\frac{1}{4}$ inch artesian wells 560 feet deep. The soil is a rich black prairie soil. Two hundred and fifty acres were irrigated in 1902.

GALVESTON COUNTY.

Six miles east of Alvin, in Galveston County, near the junction of the Chigre Bayou with Clear Creek, Berry W. Camp, of Houston, has in operation a rice farm of 1,000 acres, which yielded 86 bushels to the acre in 1901. A 150-horsepower Corliss engine operates a 15-inch Van Wie centrifugal pump, which delivers 8,000 gallons a minute (18 second-feet) against a lift of 40 feet. The water is pumped out of an elliptical basin 40 feet across and 17 feet deep, which was excavated in the banks of the bayou and walled in with sheet piling and floored with heavy timber, and is discharged into a flume 2 feet by 6 feet 2,000 feet long and delivered to the main canal, which is 25 feet wide and 2 miles long. Both the Japan and the Honduras rice were sowed, 500 acres of each, the seed being imported for the purpose; $1\frac{3}{4}$ bushels were sowed to the acre. The soil is black, from 3 to 4 feet deep with a clay subsoil. The best machinery for handling the rice has been introduced. The thresher is the latest improved. It threshes, feeds itself, stacks the straw, sacks the grain (two sacks at a time), and has a capacity of 2,000 bushels every eight hours. In 1902 800 acres were planted.

One and one-half miles south of Algoa Mr. R. B. Halley sunk seven wells from 42 to 45 feet deep early in 1901, arranging them in a battery formation, four on one side and three on the other. Two 4-inch wells connect with a 6-inch pipe, and this 6-inch pipe and a 4-inch pipe join and unite with an 8-inch pipe, while another 4-inch pipe unites with the 8-inch pipe. On the other side two 4-inch wells join with a 6-inch pipe, and this 6-inch pipe and a 4-inch pipe unite with an 8-inch pipe, which is bushed into a 10-inch pipe. The two 10-inch pipes form a T to the pumps. The operating machinery consists of a 22-horsepower Foos portable gasoline engine and an 8-inch Morris vertical suction pump. The pumps are placed 8 feet below the surface. The water rises to within 4 feet of the surface of the ground. After the pumps are started the water level is lowered 10 feet, giving a lift of from 18 to 22 feet. The soil is black prairie soil. The water supply for 1901 failed, and only 250 sacks of "Providence" rice were raised.

BRAZOS VALLEY SECTION.

WASHINGTON COUNTY.

East of the Colorado Valley and from the country along the Santa Fe Railroad to Trinity River there are a number of plants, but they can not be classed in any system geographically distinct. They are in the counties of Washington, Austin, Waller, Fort Bend, Harris, Brazoria, and Galveston. The highest plants in this group are in Washington County and take their water from Brazos River. They are owned by W. E. Buchanan, Heber Stone, and J. P. Buchanan, all residents of Brenham. In 1902 775 acres were irrigated.

The plant of W. E. Buchanan is about 18 miles from Brenham. It consists of a 35-horsepower Atlas engine and an 8-inch Morris pump, having an estimated capacity of 3,500 gallons a minute (nearly 8 second-feet) under the lift of 40 feet. The soil is that of the rich Brazos bottom lands, and 200 acres were planted in 1902.

The plant of Heber Stone is in Waller County, about 18 miles from Brenham. It consists of a 125-horsepower Beaumier Brothers' engine and a 15-inch Van Wie pump. The lift is 40 feet, and the estimated capacity 7,000 gallons a minute (15.6 second-feet). The machinery did not arrive in time for the crop of 1901, but it is the intention to irrigate 200 acres in 1902.

J. P. Buchanan's rice farm is in the neighborhood of the former, but is in Washington County. A 125-horsepower Beaumier Brothers' engine runs the 15-inch Morris pump against a lift of 40 feet, and it is estimated that the capacity is 7,000 gallons a minute. The soil is the famous Brazos bottom land. Forty acres were irrigated in 1901, yielding 50 bushels to the acre, and 625 acres were irrigated in 1902.

The floods in the Brazos in the early part of August, 1902, destroyed most of the rice in Washington County.

AUSTIN COUNTY.

In Austin County there are a few well plants. That of Hackborth & Koy is on Mill Creek, from which it takes its water, 6 miles northeast of Sealy. It consists of an 8-inch Morris pump and a 40-horsepower Erie City engine, working against a lift of 31 feet. The soil is described as a red buckshot with an admixture of black sand. Two hundred acres were irrigated during 1902.

SAN BERNARD CREEK.

Stone system.—On East San Bernard Creek James and Stephen Stone have installed an irrigation system 1½ miles from Beard, with which 390 acres were irrigated in 1900, producing, after the Galveston storm, 6 sacks to the acre, commanding $3 a sack, and 300 acres in 1901, yielding 3,000 sacks, which sold for $3 a sack. The plant consists of one 150-horsepower Westinghouse automatic compound engine, operating a No. 13 Ivens pump having 15-inch suction and 13-inch discharge pipes. The estimated capacity is 7,000 gallons a minute (16 second-feet) under a lift of 27 feet. The flume is 5 feet by 2 feet by 520 feet long, and delivers the water into a canal 2 miles long and 100 feet wide. The laterals are three-fourths mile long and 15 feet wide. The soil is light and sandy, from 1 to 1½ feet deep. Wood is used for fuel, requiring 3 cords a day for the 390 acres irrigated in 1900. The experience here in 1900 confirms the estimate of irrigators in the Beaumont section and in western Louisiana—that it requires fully 9 gallons a minute for each acre irrigated, or 1 second-foot for each 50 acres. In 1902 300 acres were irrigated.

Jahn system.—Just north of Beard G. A. Jahn and associates have opened up a rice farm with the intention of deriving the necessary water from San Bernard Creek by impounding in a reservoir of 100,000 gallons' capacity.

A crib-work dam, 350 feet long, backs the water up 1 mile and deflects it into a canal and pit. The water is then pumped, under a lift of 25 feet, into a reservoir covering 180 acres. The water is pumped out of the reservoir into the supply canals by two 18-inch Van Wie pumps. The power is supplied by a 300-horsepower Corliss engine. This company irrigated 700 acres in 1902. Ten miles southeast of Sealy, and 4 miles north of Chesterville, Dr. Magruder has constructed a dam across the Little Bernard, forming an impounding reservoir from which, with a 28-horsepower engine, he pumped water into 75 acres of rice during the season of 1902. Adjoining the San Bernardo Company, Stephen Stone has dammed a small tributary of the San Bernard, forming an impounding reservoir from which, with a 150-horsepower Westinghouse automatic compound engine and one 13-inch Ivens centrifugal pump, he raises the water into his flumes. In 1902 300 acres were thus irrigated.

FORT BEND COUNTY.

The Fort Bend Irrigation Canal Company has two pumping plants. The second plant pumps from Smithers Lake, which during average seasons has an abundance of water for ordinary purposes. The lake has a drainage area of 14 square miles, and the outlets are dammed to prevent waste. Notwithstanding this, it was evident early in the season of 1901 that the long-continued drought in the coast country, which extended practically from September 8, 1900, to September, 1901, had completely exhausted the resources of the lake. At the second lift the plant is composed of one 50-horsepower Chandler & Taylor engine and one 13-inch Ivens pump, the capacity of which, with the lift of 18 feet, is estimated to be 10,000 minute-gallons. The soil is black prairie land with a good subsoil, 400 acres of which were irrigated during the current season. The plant at the river consists of an engine of 250-horsepower, operating the pump against a lift of 45 feet. This plant pumps the water into Dry Bayou, and this in turn to Lake Bayou. A dam has been constructed across Rabb Bayou to hold the water from passing out. The acreage in 1902 was 750.

The pumping plant of the Brazos Canal Company is located on Jones Creek, 5 miles north of Richmond, Tex., and 30 miles west of Houston. The water is taken from the creek, which possesses the characteristics of a bayou and acts as a storage reservoir 17 miles long. The lands to be irrigated lie to the west of Houston and fall generally to the eastward from the pumping plant. An extra pumping plant is located on the Brazos River just below the upper junction of Jones Creek with the Brazos, and at low stages the river pumps will have to lift the water 32 feet into the reservoir. A tunnel is excavated from the bayou reservoir to the river, and when the level of the river water rises 32 feet it flows into the reservoir without pumping or it can be shut off if desired. At the second pumping plant the water will be lifted 52 feet into a canal, giving 4 feet of water in the canal, which, with the configuration of the country, can cover the lands to the east by gravity. During 1902 it is intended to irrigate 2,000 acres only.

The Brazoria Rice and Irrigation Company takes its water from the Brazos above a crossing of the Santa Fe with the Brazos. The plant consists of a 900-horsepower Greenwald engine, operating a Worthington high-lift 36-inch pump against a head of 47 feet, and has an estimated capacity of 35,000 minute-gallons. The 100-foot canal from the river conveys the water into a lake of 27 acres about 1½ miles from the river. The water is pumped out of the lake into the second canal by a 450-horsepower Greenwald engine and a 36-inch Worthington pump against a lift of 17 feet. The canals extend at present to the eastward, crossing the tracks of the Columbia Tap Railroad near Riceton. It is contemplated to construct another canal crossing the Santa Fe Railroad and irrigating land south of Arcola Junction. Only 4,800 acres were irrigated by this company in 1902.

BRAZORIA COUNTY.

In Brazoria County the following persons have plants: J. A. Bent, William Masterson, Howard F. Smith, Rod Oliver, H. and G. Munson, F. C. Baker, Judge Walker, A. H. Bartel, and John Chase. Two miles south of Arcola Junction, J. A. Bent has a small plant of about 35 acres, where a small donkey engine and a 4-inch Morris pump raise the required water from a well. The rice farm of William T. Masterson is 4 miles southwest of Sandy Point, and derives its water from Oyster Creek. A 25-horsepower Erie City engine operates an 8-inch Morris pump against a lift of 17 feet and irrigates 30 acres of rice, yielding 250 sacks. H. F. Smith's farm of 175 acres is 1½ miles north of Sandy Point, and derives its water from Jackson Lake.

The plant of Rod Oliver is 10 miles southwest of Angleton. A 25-horsepower engine operates a special pump designed by Mr. Baker, of Angleton, against a lift of 10 feet. It discharges through a vertical penstock 3 feet by 3 feet. Seventy-five acres were irrigated in 1901. The plant of H. and G. Munson is 3 miles west of Angleton, on Oyster Creek, and consists of an 80-horsepower Erie City engine, operating a 15-inch Morris pump, against a lift of 10 feet. This plant was late in being completed, but notwithstanding this 250 acres were irrigated in 1901. Only 100 acres were harvested, however, the yield being 900 sacks, which sold for $2.50 a sack. In 1902 700 acres were irrigated.

The rice farm of Walker & Cain, near Angleton, has three pumping plants. The first is located on Bastrop Bayou and consists of one 150-horsepower engine, operating two 15-inch centrifugal pumps against a lift of 10 feet and having an estimated capacity of 25,000 minute-gallons. The second plant is located on Oyster Creek and constitutes an emergency plant in times of low water in Bastrop Bayou. One 125-horsepower engine pumps the water from Oyster Creek into the canal that leads to Bastrop Bayou. A dam has been constructed across Bastrop Bayou to keep back the salt water, but it also acts as a storage reservoir for the fresh water. Plant No. 3 constitutes the second lift for the main supply canal. It is 2 miles from plant No. 1, and a 75-horsepower engine operates the pumps against a lift of 6 feet and has an estimated capacity of 15,000 minute-gallons. In 1902 1,400 acres were sown.

John Chase also obtains water for his 60 acres of rice from the Bastrop Bayou, 6 miles southwest of Angleton. He harvested only 75 acres in 1901. The pump used is of a special make, manufactured by Mr. Baker, of Angleton. It is run by a 25-horsepower Erie engine and operates under a lift of 8 feet. The crop was badly injured by salt water, the yield being 2 sacks to the acre.

J. G. Smith & Bro. own and operate two rice farms, one 6 miles north and the other 9 miles west of Columbia. The first derives its water from a lake covering 2,000 acres, but the lake failed and the result was no crop. The plant is composed of two Atlas engines of 40 and 25 horsepower and two Morris pumps, one 15-inch and the other 12-inch. The lift is 12 feet and the estimated capacity 6,200 gallons a minute. The plant was first operated in 1900, when 85 acres of rice were raised; but in 1902 the acreage was expanded to 550 acres. The second plant (9 miles west of Columbia) is to derive its water from an 8-inch well 270 feet deep, but it was not completed in time for the 1901 crop. One 40-horsepower Nagle engine runs an 8-inch Morris pump, working under a lift of 10 feet. The soil is a black, waxy prairie soil. This firm also operates a well plant of 60 acres near Guy, in the Fort Bend country.

The plant of A. H. Bartel is 6 miles from Angleton, on the Bastrop

Bayou, and consists of a 25-horsepower engine and a 12-inch Lawrence pump, operating against a lift of $8\frac{1}{2}$ feet. He irrigated 75 acres in 1901, the yield being 135 sacks. In 1902 100 acres were irrigated.

COLORADO VALLEY SECTION.

The principal rice irrigation systems of the Colorado Valley are in Colorado, Wharton, and Matagorda counties. The larger systems are indicated on the map forming fig. 24.

COLORADO COUNTY.

EAGLE LAKE.

Dunovant system.—In 1899 Capt. William Dunovant irrigated 250 acres of rice near the town of Eagle Lake. This was the first rice farm irrigated along Colorado River, and proved so successful that in 1900, 30,000 acres were irrigated in the Colorado Valley, and in 1901 56,000 acres. Water for the Dunovant plant is pumped from Eagle Lake, a beautiful, clear, fresh-water lake near the town of the same name, covering an area of about 2,500 acres and having an average depth of 8 feet. This was the first time the waters of the lake were utilized for irrigation purposes. Captain Dunovant's plant originally consisted of a 12-inch Van Wie double-suction pump, throwing 4,000 gallons a minute. The lift was 27 feet. The three boilers were old-style tubular, which were moved from a sugar mill that had been destroyed by fire. Two had two 14-inch and two 10-inch flues, and the third had two 16-inch and two 10-inch flues. The engine was a 200 horsepower. The flume, which was made of piping, had a length of about 350 feet. With this equipment 250 acres were irrigated in 1899. The plant was added to considerably in 1900. A new 21-inch Ivens pump, having a capacity of 15,000 gallons, and a 150-horsepower automatic engine were installed, and with the other operating machinery 3,000 acres were irrigated. In 1902, 3,600 acres were irrigated.

As Eagle Lake will not supply this plant and that of the Eagle Lake Rice Company, Captain Dunovant and the rice company have each erected pumping plants on Colorado River to pump water from the river to the lake.

The plant has been added to from time to time till it now consists of three pumping stations, two on the lake and one on the river. That on the river consists of a 300-horsepower engine, operating three centrifugal pumps—one 18-inch Morris, one 15-inch Morris, and one 18-inch Ivens—all working under an ordinary lift of 14 feet. The lift would have been much more than this, but the canal to convey the water from the river to the lake was so deepened that the low lift of 14 feet was secured. The old plant on the lake consists of three engines—two of 150 horsepower each and one of 60 horsepower. These operate, against a lift of 22 feet, three centrifugal pumps—one 12-inch Van Wie, one 20-inch Morris, and one 21-inch Ivens. This plant delivers the water into a flume that connects with the main canal system that crosses the tracks of the Cane Belt Railroad by means of an inverted siphon. The third plant is situated on the lake between the towns of Lakeside and Eagle Lake and is operated by an electric motor that derives its power from the engines at the gin in Lakeside. The pump is a 12-inch Morris and works under a lift of 27 feet. The water is delivered into a flume which connects with a main canal that

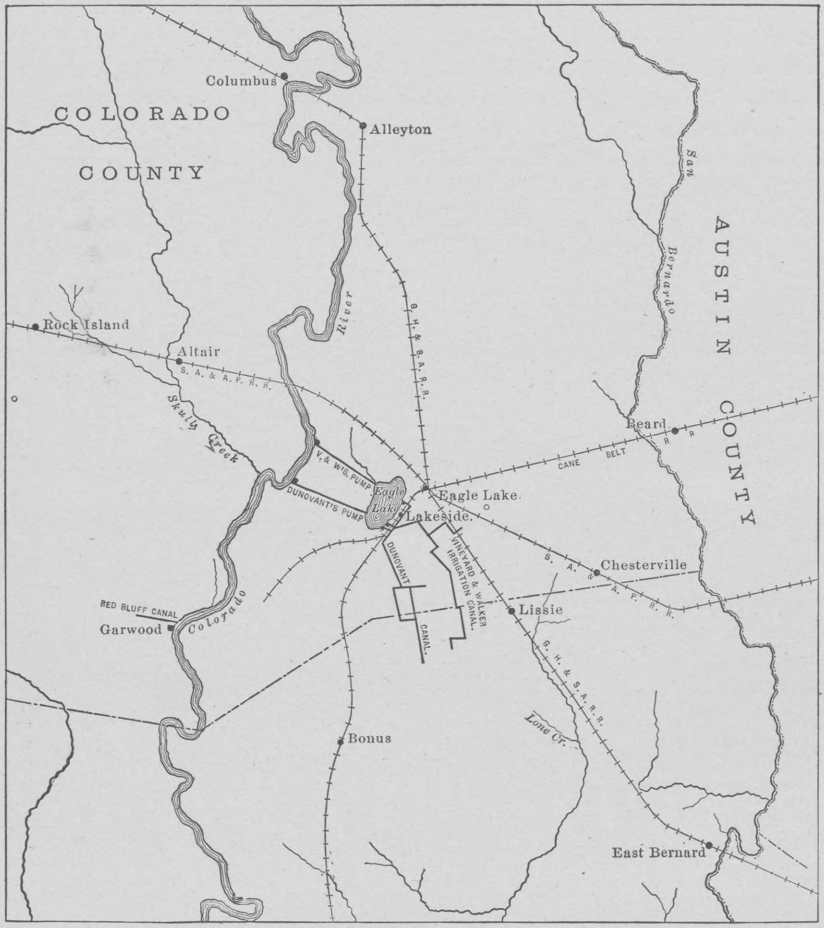


FIG. 24.—Map showing irrigation canals at Eagle Lake.

also crosses the Cane Belt tracks and there parallels the tracks crossing the canal of the Eagle Lake Rice Company's plant and connects with the canal from the original pumping stations. At these stations 80 barrels of Beaumont oil are used for fuel every twenty-four hours. In 1902 3,600 acres were irrigated.

The Eagle Lake Rice Company system (*also known as Vineyard and Walker Canal*).—This company has erected a pumping plant about one-fourth of a mile north of Captain Dunovant's, on the eastern edge of Eagle Lake, and another on Colorado River, 3 miles from the first plant. The plant on the lake consists of three 125-horsepower boilers and one 250-horsepower engine, operating a 24-inch Ivens pump having a capacity of 20,000 gallons a minute, and one 350-horsepower engine, operating a 30-inch Ivens pump having a capacity of 25,000 gallons a minute. Either of the pumps can be operated from the boilers, but both can not be operated at the same time. This plant is equipped with oil burners and storage tanks and a pipe line from the Cane Belt Railroad. The river plant consists of one 300-horsepower engine and two 150-horsepower boilers (another of the same size is being added), operating a 30-inch Ivens pump of 25,000 gallons capacity, against a maximum lift of 28 feet. The water is canalled to a branch, which takes it into the lake, and from there, in time of low water, is conveyed by means of a canal to the plant across the lake. The river plant has a 3-inch oil-pipe line 7,000 feet long leading from the Aransas Pass Railroad to the plant, also storage tanks, and is fully equipped for burning oil, which has proved a very satisfactory fuel in every way. It is cheaper in first cost, can be applied at less than half the expense for firemen, and is more effective than coal or wood.

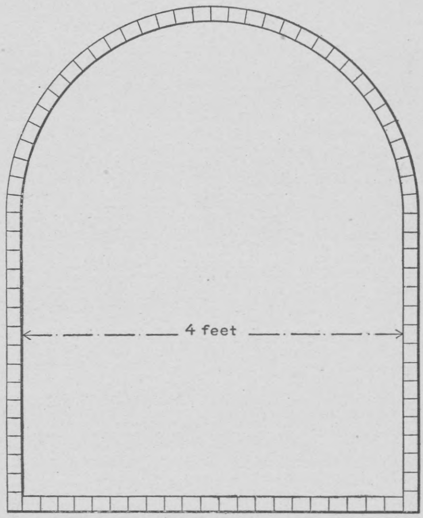


FIG. 25.—Cross section of Eagle Lake Rice Company's siphon under Cane Belt Railroad.

The canal is 60 feet wide at its head, or where the flume enters it, but after the rice farm is reached the width is increased to 100 feet. The total length of the canal is 16,840 feet. The distance from the mouth of the canal to the first gate is 4,300 feet. There are two large laterals leading from the canal, one 4,000 feet long, the other 3,000 feet long. A few hundred feet from its head the canal crosses the Cane Belt Railroad, and this crossing led to a dispute between the canal company and the railroad company. The canal was too high to go under the railroad as graded, and the company would not elevate the track so that the canal could go under. It was finally decided to carry the water under the track by a siphon. This siphon, except under the track proper, is made of brick, the cross sections and dimensions being shown in fig. 25. Owing to the jar caused by passing trains it was considered wise not to extend the brick conduit under the track. Consequently the brickwork stops on both sides, just before the track is reached, and the water is carried through by means of pipes. The falling and rising curves in the siphon are easy, so as to eliminate as much friction as possible.

The company irrigated 3,000 acres in 1900. In 1901, 3,200 acres were planted, but the supply of water in Eagle Lake failed to such an extent that only a few acres were harvested. It is the intention to sow from 3,000 to 3,500 acres in 1902. The soil on the farm is black and sandy. The contour of the land proves to be of great advantage, for after a certain distance the ground falls, making a second lift plant unnecessary.

COLORADO RIVER.

Sigler system and Harbart-Stafford Rice Company systems.—West of Colorado River, near the stations of Altair and Rock Island, on the San Antonio and Aransas Pass Railroad, several small rice irrigation plants have been introduced. On the west bank of the river a few hundred feet below the railroad bridge, in plain view of passing trains, are the pumping plants of Dr. H. C. Sigler and the Harbart-Stafford Rice Company. The rice farm of the former, which is nearest the railroad bridge, lies along both sides of the railroad track. The plant consists of an 8-inch Wells pump operated by a 35-horsepower Atlas engine. Under a lift of 34 feet the capacity of the plant is estimated at 2,500 gallons a minute (42 second-feet). The plant cost $4,500, and from it 200 acres of rice were irrigated in 1900 (producing 2,500 sacks) and 200 acres in 1902.

The plant of the Harbart-Stafford Rice Company is just below that of Dr. Sigler and west of Colorado River. It consists of a 150-horsepower Atlas engine operating an 18-inch Van Wie suction pump having an estimated capacity of 16,000 gallons a minute (35 second-feet) under a lift of 33 feet from the river level to the flume. The flume is 200 feet long, 5 feet wide, and 2 feet deep, and discharges into the main canal, which is 1½ miles long and 40 feet wide, with 2 miles of laterals 20 feet wide. The plant cost $8,000, and the company planted 350 acres of rice in 1902.

Westmoreland system.—Four miles from the Aransas Pass Railroad bridge J. W. Westmoreland has a rice farm of 225 acres. The water is taken from Colorado River by an 8-inch Morris vertical suction pump. The engine is a 50-horsepower Erie City, and the water is raised to a height of 42 feet.

Four miles east of Rock Island and 1 mile below the crossing of the San Antonio and Aransas Pass Railroad with Skull Creek the Brandon Brothers have a rice farm that derives the necessary water from Skull Creek. The plant consists of a 40-horsepower Erie City engine and an 8-inch Van Wie pump that operates against a lift of 32 feet, and during the season of 1902 irrigated 85 acres of rice.

The total rice acreage in Colorado County west of the river is as follows: From well plants, 840 acres; Brandon Brothers, 85 acres;

J. W. Westmoreland, 220 acres; H. C. Sigler, 150 acres; Harbart-Stafford, 350 acres; Red Bluff Company, 1,200 acres; total, 2,845 acres.

WELL PLANTS.

On the west side of the Colorado River, in the country lying between Rock Island and Garwood, a number of small rice farms that derive their water from wells have been opened up. The wells are somewhat similar in construction and always consist of a pit, either circular or rectangular in cross section, excavated to a depth of 18 to 22 feet, with a bored well in the bottom. This well must always extend through sufficient water-bearing sand and gravel to give flow enough for the farm. A screen must be let into the sand strata, which will keep the sand as far as possible out of the pipes and will admit sufficient water. These screens are of various forms and lengths, and upon the screens often hangs the success of the whole enterprise. The first step in a scheme of this kind is to get a well. Nothing further should be done till the well is an assured fact. The screen can be of side or end suction. In the former case the pipe is perforated with holes one-half to three-fourths inch in diameter, 2 to 3 inches apart. Around the pipe is then wrapped fine wire, almost touching, and over this a copper gauze is stretched, the mesh varying with the kind of sand, and often experience is the only sure test. The end-suction screen will be described later. The wells of Baker Brothers and W. C. Jones will serve to illustrate those west of the river in Colorado County. The Baker well has a screen 27 feet long at the bottom of a 67-foot well, while the Jones well encountered water at a depth of 34 feet, and from this depth was placed a 30-inch screen 29 feet through coarse gravel. The suction pipe is attached to the screen pipe, and generally a centrifugal pump is placed in the bottom of the pit, and the vertical shaft extends several feet above the surface of the ground. A pulley is mounted on this shaft and is operated from the engines by belts. The engines are generally, for a single well, small steam engines of 15 to 40 horsepower, or gasoline engines of 12 to 28 horsepower. A good well outfit ought to be put in for about $1,600. The well plants west of the river in Colorado County are as follows: Frank Marshall, 50 acres; Berry Brothers, 90 acres; E. D. Bone, 135 acres; W. C. Jones, 200 acres; John Duncan, 100 acres; Baker Brothers, 100 acres; Berry, Cox, Johnson, 85 acres; Will Carr, 80 acres; total, 840 acres.

Just north of Garwood the plant of the Red Bluff Rice Company takes its water from the Colorado River. The plant consists of two 150-horsepower Erie City boilers and one 300-horsepower Corliss engine. Water is pumped from the Colorado River, and 1,200 acres of rice were irrigated in 1902. The lift is 42 feet and the pump is an 18-inch Morris centrifugal and has an estimated capacity of 15,000 minute-gallons. The water is delivered into a flume 600 feet long and then into the main canal, which is 100 feet center to center of embankments and $1\frac{1}{2}$ miles long. The laterals are about 30 feet center to center of embankments and about 1 mile long.

Marshall system.—Within the neighborhood of Rock Island, on the Aransas Pass Railroad, there are a number of projected rice farms and a few that were ready at the opening of the season of 1901. Two miles south of Rock Island, Frank Marshall has a well 78 feet deep, from which water is forced by a 6-inch Morris pump operated by a 35-horsepower Erie City engine. The plant cost $1,500, and although it was late in the season before it was ready for work, 100 acres were irrigated in 1901.

Small system.—Nine miles south of Rock Island, A. W. Small owns a plant consisting of a 6-inch Morris pump and a 35-horsepower Erie City engine. The lift is 40 feet, and the plant is estimated to possess a capacity of 1,050 gallons a minute. Ninety acres were irrigated in 1901. The cost of the plant was about $1,600.

In that section lying east of the Cane Belt Railroad and between Sealy, Hungerford, and East Bernard there are twenty well plants, averaging two wells to the plant, the acreage varying from 75 to 550. These plants, lying mostly in that section bounded by Eagle Lake, East Bernard, and Chesterville, have a common bond, in that they obtain their water from the water-bearing sand lying under the upper, blacker soil. A few typical plants will be described.

Vick system.—About 2 miles east of Eagle Lake, George Vick has installed a plant to irrigate from wells. In 1900 he sunk a well 12 feet in diameter and 34 feet deep, and with an Ivens submerged pump discharging through a 5-inch force main he irrigated 125 acres of rice. The pump was operated by an Avery traction engine, which is also used for traction purposes. The water was discharged into a small flume 12 inches by 12 inches, which in turn discharged into a ditch 25 feet wide and 1 mile long. In addition to the 125 acres irrigated from the pumps, 25 acres were irrigated by damming a small stream and forming a storage reservoir. In 1900 Mr. Vick sowed $1\frac{1}{2}$ bushels to the acre, but increased this to $1\frac{3}{4}$ and 2 bushels an acre in 1901. The crop of 1900 was damaged by the Galveston storm, but notwithstanding this he realized 19 bushels to the acre, which sold for from $1.50 to $4.25 a sack. The total cost of the plant used in 1900 was $2,250. This plant is now owned and run by Hudson & Ayres. A new 45-horsepower Erie City engine has replaced the traction engine. Beaumont oil is used as fuel, and it requires about 3 barrels for a a twenty-four-hour run. In 1902 165 acres were irrigated.

Adams system.—The feasibility of using windmills for rice irrigation was thoroughly tested at the farm of Adam Adams, $4\frac{1}{2}$ miles east of Eagle Lake. He installed nine Gamble long-stroke windmills, each having a 3-inch by 14-inch cylinder and a 10-foot wheel, operating pumps having 2-inch suction and discharge pipes against a lift of 25 feet from the seven wells that furnish the water. The plant cost $825. The water is discharged into a reservoir 4 feet deep covering 15 acres and having a capacity of 174,240 cubic feet. It is estimated that the windmills have a capacity of 70 gallons a minute.

The windmills proved insufficient, and they have been abandoned. A Fairbanks-Morse 22-horsepower gasoline engine, operating a 6-inch Morris centrifugal pump, is now used to raise the water to the flume. Eighty acres were irrigated in 1902.

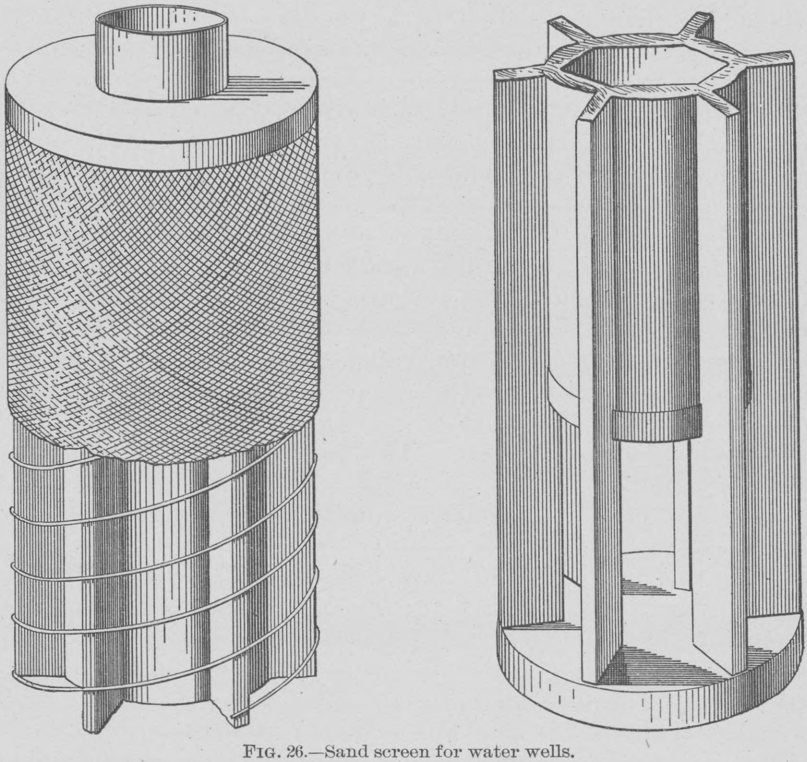


FIG. 26.—Sand screen for water wells.

A typical surface well for the Chesterville plants would be 41 to 44 feet deep, 19 feet to water-bearing sand, and then 20 to 25 feet of sand, followed by clay. A very successful screen with bottom suction 8 feet long is used in this neighborhood. It consists of a wooden pipe about 8 inches in diameter, from which 6 to 8 radial vanes project about 6 inches. A heavy wire is wrapped spirally around the vanes, making another cylinder, varying in diameter from 24 to 36 inches. Around the wrapped cylinder on top of the wire is attached a wire gauze with a mesh of 24 to the inch, which holds back the sand, permitting the water to enter. The vanes extend below the bottom of the pipe and are attached to a bottom cap, thus leaving an open space for the water to enter the bottom of the central wooden cylinder. The suction pipe of the pump is attached to the wooden cylinder near the top of the screen. A good well and a good screen are the sine qua non for a successful well plant. All failures can be traced to their absence. This is the reason that active plants of 1901 are idle in 1902. They constitute the foundation stone of success in the prairie rice farm. Without them the biggest pumps in the State could not raise water. Many plants in Texas in the last two years have been started at the wrong end. Elaborate canals, excellent machinery, fine, black, hog-wallow land are futile without sufficient water of the right kind. At plant No. 2 of John Linderholm, at Chesterville, 1,350 acres of rice were irrigated in 1901, although a late start was made. The machinery consists of a 28-horsepower gasoline engine, operating a 6-inch Van Wie pump. The plant cost $2,150; expenses, $500; and the crop paid for the plant, expenses, and the land, estimated at $12.50 per acre. This season Watt's refined Beaumont oil is used as a fuel in the gasoline engines.

Foster system.—In the neighborhood of Chesterville, 7 miles east of Eagle Lake, H. L. Foster has installed a plant to derive its water from a well. One 20-horsepower Erie engine runs a No. 4 Morris pump having 5-inch suction and 4-inch discharge, which has an estimated maximum capacity of 600 gallons a minute (1.33 second-feet) against a head of 21 feet. The canals are three-eighths mile long and 6 feet wide. Unfortunately the water supply proved a failure, and additional wells will have to be dug to obtain sufficient water for the rice land.

Linderholm system.—One-fourth mile from Chesterville, John Linderholm has three of the most effective well plants in Texas. Three No. 6 Van Wie pumps, having 8-inch suction and 6-inch discharge, and one No. 3 Van Wie pump, having 5-inch suction and 3-inch discharge, are operated by four Fairbanks & Morse engines of 34, 28, 34, and 12 horsepower, respectively, against a lift of 20 feet, estimated to have a capacity of 8,000 gallons a minute (18 second-feet). The wells are on the highest points of the land, and no flumes are necessary. Two reservoirs have been constructed, but so far they have not been utilized. The soil is a sandy loam, and the 125 acres irrigated in 1900, notwithstanding the Galveston storm, produced 8 sacks of rice to the acre, commanding $3.50 per barrel of 162 pounds. Four hundred acres were irrigated in 1901, the yield being 9½ sacks to the acre, commanding from $3 to $3.10 a barrel. Land is rented on the usual one-half plan, i. e., one-fifth of the crop for land, one-fifth for water, and one-tenth for seed. Gasoline is used as fuel. The engines are run twelve hours a day, and require 2,592 gallons of gasoline (74 per cent proof) daily, or 2 gallons per hour per horsepower. The three plants watered 550 acres in 1902.

Gray system.—Near Lissie, George Gray has installed a 28-horsepower Fairbanks & Morse gasoline engine, which operates a Van Wie pump having a 6-inch discharge pipe and an estimated capacity of 22,000 gallons a minute (5 second-feet). The plant cost $4,500. The water is supplied by two wells, one an 8-inch well 103 feet deep, with 91 feet of water, the other a 10-inch well 140 feet deep, with 115 feet of water. The main canal is three-fourths mile long and 8 feet wide. The soil is black and sandy, with a clay subsoil. One and one-fourth bushels of rice are sowed to the acre. For the land rented one-fifth of the crop is charged for land rent, one-fifth for water, and one-tenth for seed—i. e., for land, water, and seed, one-half of the crop is charged. In all 120 acres were irrigated in 1901, but the cold weather ruined 50 acres. The 70 acres saved yielded 740 sacks. A second plant has been added, and 400 acres were planted in 1902.

Malmquist system.—C. T. Malmquist irrigated 38 acres from one well by an 8-horsepower Fairbanks & Morse gasoline engine, operating one No. 4 Ivens pump having 5-inch suction and 4-inch discharge pipes, and an estimated capacity of 600 gallons a minute (1.33 second-feet) under a lift of 16 feet. The plant is 1 mile from Chesterville. The yield was 300 sacks, which sold for $3.15 a sack.

McLain system.—Four and one-half miles from Chesterville George McLain irrigates 160 acres from two wells. One Charter 18-horsepower gasoline engine runs a No. 4 Van Wie pump having a 5-inch suction and a $4\frac{1}{4}$-inch discharge. The plant has an estimated capacity of 1,200 gallons a minute (2.67 second-feet) under a head of 15 feet. Only 5 acres were planted in 1900, and the crop was considerably damaged by the Galveston storm. The soil is black and waxy, and produced 7 sacks to the acre in 1900. The water supply failed in 1901, and Mr. McLain raised no rice.

Townley system.—The plant of J. C. Townley, three-fourths mile from Chesterville, consists of one No. 8 Morris pump having 9-inch suction and 8-inch discharge, operated by a 35-horsepower Erie City engine. The lift is 20 feet and the estimated capacity 1,700 gallons a minute (3.8 second-feet). The soil is black and sandy. Two hundred acres were irrigated in 1901. The plant, exclusive of land, cost $3,000.

Electric system.—Instead of having several distinct power plants, each to carry its own pump and acreage, the Bernard Rice and Irrigation Company (C. B. Sloat, manager) has erected on its plant, 2 miles east of Lissie, a central power plant, consisting of a steam engine and boiler of capacity sufficient to carry two whole pumping plants. The power is conveyed to a 75-kilowatt electric motor, and by this the power is transmitted electrically by wire to smaller motors of 20-horsepower capacity at the three pumping plants on the farm. The experiment will demonstrate clearly the most economical method of operating plants where pumps are located in different parts of the farm.

WHARTON COUNTY.

Hudgins Brothers system.—Seven miles east of Wharton the Hudgins Brothers have opened up a large rice farm and are giving wells a full and fair test. They have in all eleven wells; seven are 44 feet deep and four are 36 feet deep. The pumps are about 13 feet below the surface. There are ten No. 3 and one No. 1 Van Wie rotary pumps. The former cost, exclusive of freight, $85 each, the latter $115. The pumps are operated by gasoline engines, five of 22 horsepower and one of 16 horsepower. Eleven hundred acres of Japan rice were irrigated in 1901, but only 450 in 1902.

The acreage from well systems in the section between Sealy and Hungerford is shown in the following: Hudson & Ayers, 165 acres; W. W. Miller, 200; R. B. Dobbins, 100; J. E. Irvin, 40; Adam Adams, 80; John Linderholm, 550; J. C. Townley, 200; C. T. Malmquist, 60; W. S. Strickland, 100; George McLain, 150; George Gray, 400; Bernard Rice Company, 205; H. Cordz, 300; Paul Jackets, 80; McBride & Lester, 100; W. S. Moore, 100; L. Pietsch, 170; Longworth & Caylor, 300; Hudgins Brothers, 450; J. M. Everett, 140; total, 3,890 acres.

EL CAMPO SYSTEMS.

In the section of Wharton County west of the Colorado River, along the line of the New York, Texas and Mexican Railroad, near the stations of Pierce, El Campo, and Louise, more well plants are in operation than in any other section of Texas. Two systems of wells are used, the shallow and the deep. The shallow wells are all of one general type. A pit, rectangular or circular in cross section, is excavated to the depth to which the water will rise, and in the bottom of the pit one or more wells are bored through or into the water-bearing sand or gravel. In this is placed the screen. The pits vary in depth from 10 to 19 feet, and the wells from 40 to 70 feet. The soil is generally black and sandy, underlain by clay, which lies over the water-bearing sand. The Milner well, a mile west of Pierce, will serve as a type for the deep wells. This well is 180 feet deep, 10-inch bore, and has 60 feet of screen. The log shows 14 feet of black soil, thick stratum of red clay, 6 feet of quicksand, 4 feet of clay, 16 feet of coarse sand and gravel, and three thin layers of clay alternating with thicker strata of sand and gravel. This well and its companion shallow well (both in the same pit) constitute in their combined capacity by far the best well found in the Texas rice belt. One of the best shallow-well plants found in this section is that of Fred Blumquist, 1½ miles east of El Campo, which is described later.

A few typical plants are here described.

Brunes system.—The plant of Chris. Brunes is just east of the Beard plant. It consists of a 5-inch Morris pump operated by a 20-horsepower Advance traction engine. The well is 48 feet deep, the water rising to within 19 feet of the surface. The head is 24 feet and the capacity estimated at 800 gallons a minute. The engines, pumps, belts, etc., cost $1,500. Fifty acres were irrigated in 1901, yielding 785 sacks, commanding $3.10 a sack.

Nordin system.—P. H. Nordin's plant is 2 miles north of El Campo. The well is 48 feet deep, the water being 20 feet below the surface. He uses a 20-horsepower J. I. Case traction engine and a 6-inch horizontal centrifugal pump. The capacity is estimated to be 700 gallons a minute under a head of 21 feet. The engine and pumps cost $1,350. Fifty acres were irrigated in 1901, yielding 413 sacks.

Just east of this plant is the plant of J. B. Carlson, which irrigated 50 acres of rice in 1900, the yield being 350 sacks. The pit of the well is 8 feet in diameter and 25 feet deep; the bored part of the well is 27 feet, making a total depth of 52 feet. The pump, a 6-inch Van Wie, is in the bottom of the pit, and has a lift of 26 feet. It is operated by a 16-horsepower Fairbanks & Morse gasoline engine. A test made at this plant shows that it requires 46 gallins of gasoline each twenty-four hours, or nearly 3 gallons to the horsepower. In carload lots the gasoline costs 12 cents a gallon, delivered at El Campo.

A second pumping plant run by a traction engine is conducted by Mr. Carlson.

Olesen system.—Five miles north of El Campo is the rice farm of D. Olesen. The well is 52 feet deep, 7 feet in diameter for 25 feet and bored the rest of the way. As at all of these plants, the water is pure, fresh, and as clear as crystal. The plant consists of a 5-inch Morris vertical pump and a 20-horsepower Advance compound traction engine, and cost $1,500. The pumps are 22 feet below the surface of the ground, giving a lift of 27 feet. The estimated capacity is 750 gallons a minute. Thirty acres were watered in 1901, the yield being 150 sacks.

Higbee system.—In 1901 R. E. Higbee irrigated 98 acres of Honduras rice, the yield being 1,500 sacks. The soil is a black hog-wallow. The well is 48 feet deep, the water rising to within 13 feet of the surface. The plant is 1 mile east of El Campo and consists of a 6-inch Van Wie pump and a 25-horsepower J. I. Case engine. The lift is 17 feet, and the capacity estimated at from 1,200 to 1,500 gallons a minute.

Berglund system.—P. E. Berglund uses a 35-horsepower Weber gasoline engine and a 6-inch pump. His well is 34 feet deep, the water level being 12 feet below the surface. The rice is sowed with a seeder attached to the hind gate of a wagon. Thirty-five acres were irrigated in 1901, the yield being 450 sacks.

Blumquist system.—One and one-half miles east of El Campo Fred Blumquist irrigates 35 acres, the yield in 1901 being 741 sacks, 4 bushels to the sack. He sold part for seed rice at $3.25 to $3.50 a sack. His pumps are in a pit 8 feet by 10 feet. The well is bored in the bottom of the pit to a depth of 30 feet, making the total depth of well 40 feet. The pump is a 5-inch Morris horizontal rotary working under a lift of

15 feet, and the engine a 14-horsepower Foos gasoline. The cost of all was $970.

Danielsen system.—The pump, lift, and engine of A. Danielsen are similar in all respects to those of Blumquist. Sixty acres were irrigated in 1902, yielding 700 sacks, which sold for $3 a sack.

Embry system.—The farm of J. R. Embry is $4\frac{1}{2}$ miles east of El Campo. The soil is a black hog-wallow. Ninety acres of rice were irrigated in 1901, yielding 625 sacks. The pit is 4 feet by 16 feet by 6 feet deep. Two 8-inch wells were bored in the pit to a depth of 34 feet, making a total depth of 40 feet. The water rises to the bottom of the pit. An 18-horsepower gasoline engine runs the 6-inch Morris horizontal rotary pump against a lift of 8 feet.

Schult system.—Six miles east of El Campo Oscar Shult has opened up a rice farm on which 100 acres of rice were irrigated in 1901, the yield being 858 sacks. The source of water is a well 39 feet deep. The pit is 8 feet by 9 feet by $9\frac{1}{2}$ feet deep. The bored part (30 feet) is 14 inches clear diameter. The machinery consists of an 18-horsepower gasoline engine and a 6-inch Morris horizontal rotary pump. The soil is a black hog-wallow, and both the Honduras and the Japan rice will be tried. Fifty-five pounds of Japan ($1\frac{1}{3}$ bushels) and $1\frac{1}{2}$ bushels of Honduras were sowed to the acre.

The well camps around El Campo are all similar, the greatest variation being in the machinery of operation. No attempt is made to give the individual peculiarities of each plant, as a few typical plants cover the essential features. The extent of the well system tributary to El Campo and Pierce is shown by the following list: O. R. Johnson, 153 acres; Oscar Nelson, 60; A. Danielsen, 80; Fred Blumquist, 120; A. P. Olesen, 60; R. E. Higbee, 70; N. Thompson, 200; A. Burglund, 50; T. Rolf, 40; Axel Bard, 60; J. W. Leech, 160; W. H. Waugh, 100; J. R. Embry, 75; Johnson & Jensen, 70; Oscar Schult, 250; James Milner, 750; P. A. E. Nelson, 50; A. P. Borden, 50; N. J. Sunwall, 50; M. Barnhardt, 25; A. P. Borden, 50; W. S. Wood & Co., 300; Chris Brunes, 105; P. H. Nordin, 105; Boehm Brothers, 60; J. B. Carlson, 175; Nelson Brothers, 200; Fritz Bender, 60; A. E. Carlson, 75; Woolsey, 120; A. S. Thompson, 75; O. B. Scroggins, 50; W. S. Louis, 75; E. G. Sterner, 150; L. Cahn, 60; John Bacek, 30; William Neizer, 50; Frank Garetzky, 50; John Wetzel, 50; T. A. Hill, 120; total, 4,200 acres.

Louise systems.—Near Louise station, on the Texas Mexican Railroad, over 1,200 acres of rice were sowed in 1902, but of the seven plants only two had sufficient water. A successful typical well here has hardly been formed. The well of W. G. Davis presented some peculiarities. At 96 feet a granite-like rock was encountered, and the drill cut through a 4-foot layer of this, making the well 100 feet deep in all. The suction pipe was set directly on top of this rock, and no screen was used. The well furnished more than an ample supply of clear, fresh water. The machinery consists of a 22-horsepower Foos gasoline engine and a 6-inch Morris pump. Sixty acres of Japan rice were irrigated during the season of 1902, but the well had water for double this acreage. The following is a list of the plants near Louise, with the amount of rice sowed: W. G. Davis, 60 acres; G. W. Barnett, 50; Otto Peterson, 40; E. M. Clark, 400; Saddler & Rome, 250; Saddler & Thomason, 200; Saddler & Thomas, 240; total, 1,240 acres. When visited in July the only plants that had water on them were the Davis and the Peterson, and it is very probable that the Louise plants will not average over half a crop this year.

JACKSON COUNTY.

Moritz and Mayfield systems.—Near Ganado, just over the line in Jackson County, M. P. Moritz and D. B. Mayfield have opened up rice farms of about 100 acres each. The former uses a 5-horsepower gasoline engine to pump from a well 56 feet deep with 20 feet of water-bearing sand. It is estimated that in a dry year one good well will irrigate 80 acres of rice. The Mayfield plant adjoins that of Moritz, and derives its water from a well 67 feet deep with 30 feet of water-bearing sand.

The acreage around Ganado in 1902 was as follows: D. B. Mayfield, 50; N. P. Mauritz, 200; A. W. Everitt, 50; L. Ward, 75; Boquette, 60; total, 430 acres.

COLORADO RIVER BELOW WHARTON.

Bay Prairie Irrigation Company system.—Eight miles below Wharton and surrounding Lane City is the rice farm of the Bay Prairie Irrigation Company (often called the Lane Company). The pumping plant is on the banks of Colorado River, from which it takes its water, at a distance of 16,700 feet from the depot at Lane City. There were two pumping plants in 1901, but it is intended to add a third in order to bring more land under ditch. When completed the system will command 15,000 acres. The plant at the river consists of two Van Wie pumps having 54-inch discharge, operated by a Bates-Corliss engine of 1,250 horsepower. The lift is 33 feet, and the capacity is estimated at 70,000 gallons a minute. The engineer, L. E. Beadle, estimates that it will require 8 gallons a minute for each acre, but he has provided for emergencies by installing pumps having a capacity of 10 gallons a minute for each acre. There are two flumes, one at the river and the other across Jarvis Creek. The former is 5 feet by 12 feet by 182 feet long, while the latter, which is $1\frac{1}{4}$ miles from the river, is 4 feet by 20 feet by 350 feet long. There are 11 miles of main canals 120, 100, and 80 feet wide. At the second lift an Atlas-Corliss engine of 200 horsepower operates a 24-inch Van Wie pump estimated to have a capacity of 30,000 gallons a minute under the lift of 5 feet. The soil is black. The farm lies on each side of the Cane Belt Railroad. The water is carried under the tract by a terra cotta and timber invert. The plant, exclusive of land, cost \$125,000. Six thousand five hundred acres were irrigated in 1901. It is intended to increase this in 1902 to 15,000 acres. This company offers the most liberal terms to renters of any irrigation systems examined. It furnishes land, water, and seed for three-sevenths instead of one-half of the crop, thus giving the renter an advantage of 6 per cent.

Since writing the above the third lift has been added and the plant at the second lift has been transferred to the third lift. The capacity of the river plant is now 120,000 minute-gallons, and the plant at the second lift consists of one 250-horsepower engine, operating a 45-inch

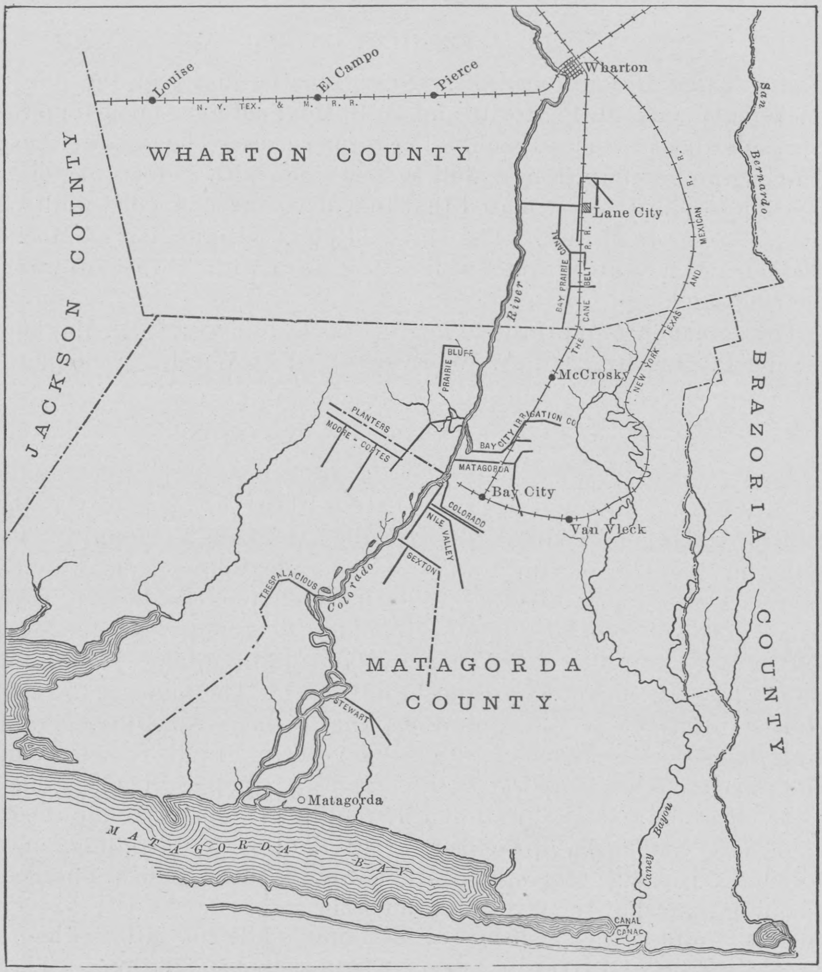
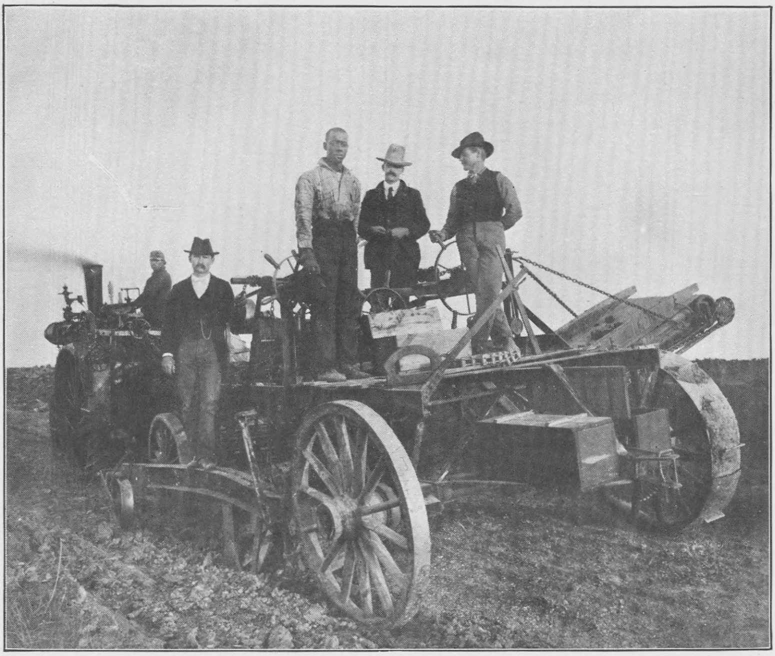


FIG. 27.—Map showing irrigation systems in Colorado Valley below Wharton.

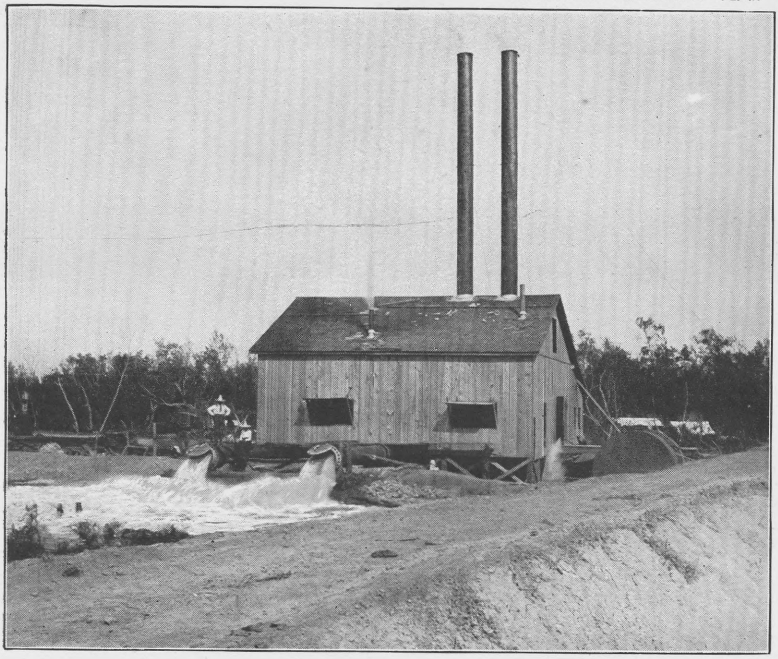
centrifugal pump which has a capacity of 50,000 minute-gallons; at the third lift, a 200-horsepower Atlas-Corliss engine, operating a 24-inch Van Wie pump, which, with the lift of 3½ feet, has a capacity of 20,000 minute-gallons. In 1902 there were under the first lift 9,500 acres, under the second 5,000, and under the third 1,500, making a total of 16,000 acres under canal, and 15,000 acres of these were irrigated during the current season.



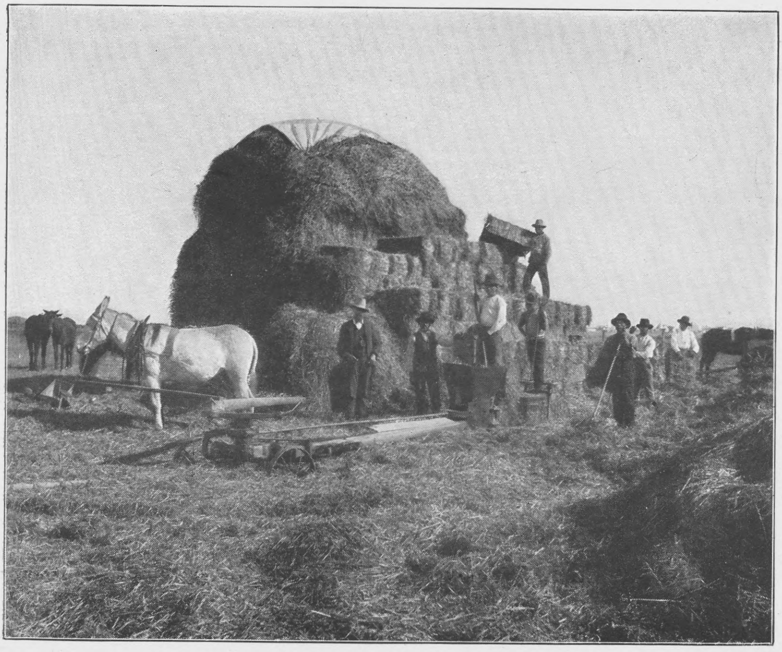
A. BUILDING LEVEES FOR RICE-FARM CANALS, WITH ENGINE AND GRADING MACHINE, IN MATAGORDA COUNTY.

B. BREAKING SOD WITH ENGINES, FOR RICE PLANTING, NEAR BAY CITY, MATAGORDA COUNTY, MARCH, 1902.

Capacity of engine, about 50 acres per day and night.



A. NILE VALLEY PUMPING PLANT.



B. BALING RICE STRAW FOR HAY, NEAR BAY CITY.

MATAGORDA COUNTY.

Near Bay City, in Matagorda County, eight large companies have opened up extensive rice farms. The Bay City Irrigation Company, the Nile Valley Company, the Colorado Company, the Stewart, the Sexton, and the Matagorda Rice and Irrigation Company have plants on the east side of the river, while the Moore-Cortez, the Planters, the Prairie Bluff, and the Trespalacious are on the west side, as shown by fig. 27. Not only is heavy machinery used in pumping the water, but the heaviest traction engines are used both in making the levees and in plowing the land. One traction engine of 30 horsepower, with its plows, can break up 2 acres per hour. Pl. VIII, *A* and *B*, shows the methods of levee making and steam plowing.

Moore-Cortez Canal Company system.—The Moore-Cortez Canal Company installed for the season of 1901 a large plant about 6 miles from Bay City. They own and control 20,000 acres of land, and have located their pumps on a small lake. The plant consists of one 300-horsepower Vilter-Corliss engine, operating an Ivens centrifugal pump having two 30-inch suction pipes, and an estimated capacity of 56,000 gallons a minute (124 second-feet) under a lift of 12 feet. The main canal is 7 miles long and 100 feet wide. The length of the main laterals is 10 miles and the width 40 feet. The whole plant, exclusive of land, cost $50,000. Five thousand five hundred acres were irrigated in 1901, yielding 10 sacks to the acre, selling for from $2.50 to $4.50 a sack. For the part of the land that is rented the company charges one-fifth of the crop for land rent and one-fifth for water. In 1902 10,000 acres were irrigated.

Bay City Irrigation Company system.—The pumping station of the Bay City Irrigation Company (Victor La Tulle, manager) is 3 miles north of Bay City and takes water from a lake connected with Colorado River. The plant consists of two 24-inch Morris pumps and two 140-horsepower Erie City engines. The capacity is 50,000 gallons a minute (111 second-feet) under a head of 12 feet. The water is delivered into a flume 3 feet by 12 feet 100 feet long. There are 7 miles of main canals, 125 feet from center to center of embankments. The cost of the plant, exclusive of land, was $30,000. The soil is a black hog-wallow with a slight admixture of sand. The plant was operated for the first time in 1901, when 4,000 acres of rice were irrigated, producing 10 sacks to the acre. This plant watered 5,000 acres in 1902.

Matagorda Company system.—Adjoining the lands of the Bay City Company are those of the Matagorda Company. The pumping plant is 2 miles northwest of Bay City, and consists of one 360-horsepower Greenwold engine and one 100-horsepower Nagle engine. There are two Worthington pumps and one Menge pump. The discharge pipes of the Worthington pumps are 20 inches by 40 inches, while the Menge pump discharges through a penstock 6 by 6 feet. The joint capacity of the former is 64,000 gallons a minute and of the latter

22,000 gallons a minute, or a total of 86,000 gallons (191 second-feet), under a lift of 98 feet. It is to be remarked that this is about equal to the lowest flow of Colorado River at Austin. The total cost of the plant, exclusive of land, was about $55,000. The plant was used to irrigate 540 acres of land in 1900, the yield being 12 sacks to the acre, which commanded $3.60 a sack, net. In 1902 the acreage was increased to 9,000 acres.

Colorado Company system.—Near the Matagorda plant is that of the Colorado Canal Company. This plant is located on an intake connecting with a lake, which in turn at certain stages of the river connects with it. The machinery consists of a Murray Brothers 200-horsepower compound condensing engine and a Connersville blower pump, with discharge pipe 32 by 96 inches. The lift varies from 8 to 12 feet, depending upon the stages of the river and lake. It requires 20 barrels of Beaumont oil per day, which costs at Bay City 43 cents per barrel, making a total cost of $8.60 per day for fuel. The capacity of the plant is 50,000 minute-gallons. During the present season 5,300 acres were irrigated.

Nile Valley system.—The Nile Valley plant is on the banks of the Colorado River, less than one-fourth mile from that of the Colorado Company. This plant takes its water directly from the Colorado River one-half mile above the head of the famous raft. Two 80-horsepower duplex engines operate the two 30-inch Morris pumps against the maximum lift of 8 feet. The canal of this company forms a levee and serves to protect Bay City and the lands below. Twenty-two barrels of Beaumont oil are used per day. In 1900 2,500 acres were irrigated from this canal. Pl. IX, *A*, is a view of the pumping plant at the Nile Valley plant.

Stewart system.—At the Stewart canal an 80-horsepower engine operates a 24-inch Morris pump against a maximum lift of 21 feet. In 1902 1,700 acres were irrigated by this canal.

Sexton system.—The Sexton plant uses a simple 80-horsepower Greenwald engine and a Menge pump under a lift varying from 18 to 20 feet. This plant irrigated only 500 acres this season. On the west bank of the Colorado River two new plants have been projected, the Trespalacious and the Planters. The former is below Bay City, while the latter takes its water from below the Moore-Cortes pumping plant, but its canal crosses that of the Moore-Cortes Company and irrigates land above. The Planters Canal Company was late in starting, and only 950 acres were irrigated in 1902. The Prairie Bluff Rice Company has located its canal on Blue Creek above the Moore-Cortes and the Planters canals. It also was late in starting, and during the current season irrigated 350 acres of rice.

Summary of Matagorda plants.—Following is a summary of the Matagorda County plants: Bay City Irrigation Company, 5,000 acres; Matagorda County Rice Company, 9,000; Colorado Company, 5,300;

Nile Valley Company, 2,500; Stewart Canal Company, 1,700; Sexton Canal Company, 500; Prairie Bluff, 350; Moore-Cortes, 10,000; Planters Canal Company, 950; S. J. Cleveland, 160 acres; total, 35,460 acres.

GUADALUPE RIVER.

DEWITT COUNTY.

The only water-power plant in Texas that irrigates rice is that of Otto Buchel, 3 miles north of Cuero. A masonry dam across the Guadalupe River produces an effective head of 10 feet. This is one of the most substantial dams in Texas, and it cost, with its equipment, $100,000. The power is generated by 54-inch turbines, which operate the pumps to raise water into an adjacent reservoir. An auxiliary steam plant of 400 horsepower is used for supplementing the energy generated by the water plant. This plant furnishes power for three rice farms—Mr. Buchel's, Schleicher & Crouch's, and Rathbone and Wofford's. The farm of Schleicher & Crouch is above that of Buchel and on the east side of the river. The power for operating the pumps is transmitted electrically from the Buchel power plant. The farm of Rathbone & Wofford is on the west side of the river, and also receives its power by electric transmission from the Buchel plant. In all, 750 acres of rice were irrigated at these farms in 1902.

VICTORIA COUNTY.

The plant of the Victoria Rice and Irrigation Company is located 10 miles south of Victoria, and takes its water from the Guadalupe. On the east side, at the first lift on the river, there are two 235-horsepower Brownell engines operating the pumps against a lift of 22 feet. The river plant delivers the water into a flume 1,400 feet long, and this empties into a reservoir 24 by 125 feet by 9 feet deep. The second lift is 41½ feet, and two 525-horsepower Corliss engines operate the pumps. The second flume is 400 feet long and delivers the water into the main canal. There are 5 miles of 100-foot canals, 2 miles of 75-foot laterals, and 2 miles of 60-foot laterals. The highest point of land to be irrigated is 62 feet above the ordinary water level of the river, and there is a fall of 18 inches from the second lift to this highest land. In 1902 2,700 acres were irrigated. Wood is used as fuel at present, but it is the intention to substitute Beaumont oil soon, transporting it down the canal by boat to the plants.

Four miles west of Victoria Harry Rathbone has 60 acres in Japan rice this season. He derives the water from Pridhams Lake, and a 6-horsepower engine operates the 5-inch centrifugal pump under a lift of 8 feet. The soil is sandy river bottom. Twelve miles above Victoria John T. Rusk has a well-plant rice farm, but lateness in obtaining water renders its acreage doubtful for this season.

BROWNSVILLE IRRIGATION SYSTEM.

The center of rice culture in Texas takes its way considerably westward for 1902, on account of the big irrigation system near Brownsville, on the Lower Rio Grande. During 1901 this system was experimental, consisting of the machinery of an unused irrigation plant. The experiment was so successful, however, that the company, the Brownsville Land and Irrigation Company (W. M. Ratcliff, manager), has made plans to extend the system on a large scale, at a cost of $250,000. The plant is 5½ miles below Brownsville. Rice, sugar, and cotton will be raised by irrigation. The plant now consists of one 300-horsepower Chandler & Taylor engine and an Ivens centrifugal pump, having 28-inch suction and 24-inch discharge pipes, and an estimated capacity of 80 second-feet under the lift of 11½ feet. The horsepower of the engine, if actual, ought to treble this discharge. The water is first pumped into a flume 3 feet by 18 feet by 40 feet long, and then is delivered into the canals. The main canal is 12 miles long and 120 feet wide, and there are 16 miles of laterals 100 feet wide. The fuel used is mesquite wood.

AREA DEVOTED TO RICE CULTURE, BY COUNTIES.

	Acres.		Acres.
Jefferson	44,380	Cameron	3,000
Matagorda	35,460	Victoria	2,770
Wharton	23,600	Austin	1,220
Liberty	16,200	Galveston	800
Colorado	11,450	Washington	780
Orange	10,850	Dewitt	750
Harris	9,100	Jackson	430
Chambers	9,000	Waller	400
Fort Bend	8,830		
Brazoria	3,150	Total	182,170

PROPOSED PLANTS.

In addition to the systems described above there will be several big plants operating in 1903. The Treadway Canal Company will take its water from the Neches River 8 miles northwest of Beaumont and irrigate land on each side of the Southern Pacific Railroad. It is contemplated to bring 25,000 acres in cultivation by this canal. The canals are already under construction.

The Texas Land and Irrigation Company is installing a plant to take its water from the Brazos River northeast of Wallis. Its canal, already under construction, will extend in a southerly direction, and it is intended to bring the land between Wallis, Rosenberg, and East Bernard under canal.

The Illinois Irrigation Company proposes to take out a canal from the Brazos River north of Sealy, near San Felipe, and irrigate lands north and south of Sealy.

The San Jacinto Rice and Irrigation Company expects to put in a plant on the San Jacinto River east of Houston in 1903.

The Wallace-Radford Company intends to irrigate lands east of Eagle Lake by a canal system to take water from Colorado River.

APPENDIX.

The following statement of the Texas laws pertaining to irrigation was prepared by Judge John C. Townes, professor of law in the University of Texas:

A water course, as the words are used in this connection, has been defined as "a stream usually flowing in a particular direction, though it need not flow continually. It may sometimes be dry. It must flow in a definite channel having a a bed, sides, or banks, and usually discharges itself into some other stream or body of water." 27 WIS., 661. COOLEY TORTS, 238.

It will be observed that the water supply need not be sufficient to cause the stream to flow all the time. It must flow habitually, though not necessarily uninterruptedly. There must be a definite channel; that is, a bed or place where the water passes along over the same depression or lower surface, which is bounded or limited by ascertained and definite sides or banks. When these things occur, the water thus confined and seeking a regular outlet is a water course or stream. Water standing in a depression and not flowing is not a stream. Water flowing not in a defined channel, as surface water after a rain, is not a stream. In our changeable climate it is sometimes difficult to determine the question as a fact regarding any particular body of water. Sometimes there is a well-defined channel, but no water except immediately after rains; again there are channels down which water flows frequently, but not continuously. How often it is to run and how long during the year must be answered from the facts in each case. If there is a well-defined channel down which water passes usually—habitually—it is enough, though it may sometimes be dry. If, however, it is usually dry, with water flowing in it only occasionally, it is not a stream.

The water passing in these streams is not owned by anyone. The proprietors of the land crossed by or bordering on the stream have legal rights in its use, but have no property in the water itself. These rights, like all others, have their correlative duties, and the proprietors of the several estates must have regard at all times to the obligations under which each rests toward the other. All persons who own land along a stream are coproprietors in its use. These uses are of two kinds—domestic or natural on the one hand, and artificial or commercial on the other hand. As to the first, the right of use is very extensive, and the proprietor who first gets access to the water lawfully may completely exhaust it in these natural or domestic uses without incurring liability in so doing. It is not so with the second—the artificial or commercial use. Here no one has an exclusive privilege. The upper proprietor can use it for these purposes provided that after this use he permits it to leave his land at the same place, in the same quantity, and of the same quality that it would have but for such use.

It is apparent that the rights and liabilities of the parties vary greatly as the use made of the water is of the one or the other class. It therefore becomes important to understand what uses fall in each class. Domestic or natural purposes embrace drinking purposes for one's family and his own domestic animals, culinary purposes, and washing, and all the uses about one's premises necessary to sustain life. Artificial or commercial uses are all those in which water is not used directly to sustain life or to give comfort, but is a means of pecuniary profit or indirect means of comfort. This seems to be the line of separation. It works out different results in different localities. It seems to be considered everywhere that the uses mentioned under the head of domestic purposes are such, and that for any of these purposes the upper proprietor or the one first getting lawful access to the water may use it to the entire exhaustion of the supply.

The following are the decisions of the supreme court of Texas:

FLEMING *v.* DAVIS, 37 TEX., 173; APPEAL FROM SAN SABA COUNTY, 1872.

Syllabus 2.—Irrigation of land, however beneficial in some portions of this State, is not one of the natural wants which will justify the owner of a head spring in exhausting the water which flows from it, to the injury of proprietors lower down on the natural channel of the stream. The maxim *sic utere tuo ut alienum non loedas* applies. The case of Tolle *v.* Correth, 31 Tex., 362, is not understood to have decided a contrary doctrine.

Syllabus 3.—In the distribution of the water of a natural stream among the riparian proprietors the principles of the common law furnish the only rules judicially known in this State; and a suit, it seems, can not be sustained to partition a natural stream among riparian proprietors by allotting to each a specified time to appropriate its waters.

BAKER *v.* BROWN, 55 TEX., 377; APPEAL FROM SAN SABA COUNTY, 1881.

Syllabus 1.—The right to use water for purposes of irrigation, when its use is not indispensable, but is resorted to for the purpose of increasing the products of the soil, must be subordinate to the right of a coproprietor to supply his natural wants and those of his family, tenants, and stock, by using the water for necessary and domestic purposes.

Syllabus 2: Limitations; riparian rights.—The rights of a riparian proprietor to the use of the water may be restricted or lost by grant or by prescription, under such adverse, continuous, uninterrupted user and occupation by another as would, by analogy to the statute of limitations, bar the right of entry upon lands. Ten years' use and occupation would in Texas be the period of prescription.

MUD CREEK IRRIGATION CO. *v.* VIVIAN, 74 TEX., 171; APPEAL FROM KINNEY COUNTY, 1889.

Syllabus 1: Irrigation corporations.—An irrigation company chartered under general law and whose charter designates the locality of its canals acquires thereby no exclusive right to the use of the waters of a flowing stream on which it depends for its supply. By virtue of the charter of its incorporation, which authorized the acquisition by gift, purchase, or condemnation of all property necessary to the irrigation enterprise, it secured the right to obtain in the manner designated the privilege of using the water of a stream, but the charter did not *proprio vigore* confer that right in the absence of a purchase, gift, or condemnation.

Syllabus 2: Constitutional law.—The legislature can not destroy or impair the vested rights of a riparian proprietor by conferring a special privilege on an irrigation company without providing for the payment of a just compensation.

Syllabus 3: Riparian proprietors; irrigation cases reviewed.—Tolle *v.* Correth, 31 Tex., 365, and Fleming *v.* Davis, 37 Tex., 173, reviewed, and the doctrine announced that a riparian proprietor has the right to divert water flowing along or through his land to purposes of irrigation, although the effect of such use is to leave to a riparian proprietor on the stream below him a supply of water insufficient for irrigation. No opinion is expressed as to whether water can be used by a riparian proprietor for irrigation so as to render insufficient the supply for ordinary use to those owning land lower down the stream.

Syllabus 4: Prescription.—A prescriptive right to use water for irrigation will be acquired by the uninterrupted use of the water for such purpose under a claim of right. But this right can only be enforced against riparian proprietors on the stream below when the water has been continuously used for ten years under a claim of right. It can not be asserted against a riparian proprietor by or through whose land the water flowed before it reached the point below where it is appropriated by the one claiming the prescriptive right.

Syllabus 5: Presumption of grant.—The presumption of a grant from long continued enjoyment can exist only as against those who might have prevented or interrupted the use of the subject of the supposed grant.

In rendering the opinion in this case, Judge Gaines said:

"It is true that the act of March 10, 1875, provides that 'any * * * canal company shall have the free use of the waters and streams of the State,' but the provisions of that act applied as well to ordinary companies as to corporations. Laws, 2d sess., 14th Leg., 77. Besides, we are of the opinion that the provision could be held only to apply to streams upon the public lands of the State, since the legislature had no power to take away or impair the vested rights of riparian owners without providing for the payment of a just compensation. If the defendants or the owners of the land along the stream in controversy had the right to use the water for the purpose of irrigating their lands, that right remained unaffected by the plaintiff's incorporation or by the legislation of the State passed for the encouragement of irrigation. It seems to be the rule of the common law that a riparian owner has no right to use the water of the stream for irrigating his lands, provided it interferes with the uses of the water by those who own the lands upon the stream below. That this is a proper rule in England and in those States where the rainfall is sufficient for the purposes of agriculture we freely concede, but we are of opinion that in those sections where irrigation is necessary to the successful pursuit of farming it should not apply. What is not a necessary use in the one case becomes necessary in the other. Evans *v.* Merriweather, 3 Scam. (Ill.), 496. It was so held in Tolle *v.* Correth, 31 Texas, 365, and though this decision was criticised in the subsequent case, Fleming *v.* Davis, 37 Texas, 173, we are of the opinion that it recognizes a correct rule of law as applied to the present case.

"We think it a matter of common knowledge that there are portions of our State where the business of agriculture can not be successfully prosecuted through successive years except by irrigation, and it is to be inferred from the allegations of the petition that the section where the stream in controversy is situated is of that character. We think, therefore, that the defendants had the right to divert the water which flowed in the stream along or through their lands for the purpose of irrigating them, although the effect of such use was to leave the plaintiff corporation an insufficient supply for the same purpose. Whether they had the right to divert the whole of it and leave an insufficient supply for the ordinary use of the lower riparian owners we need not in this case determine."

From these cases it is clear that the purposes named above as domestic are regarded as such in this State, and that irrigation ordinarily is not such a use, but that if in any particular locality the business of agriculture can not be successfully prosecuted through successive years except by irrigation, such use in such locality may be regarded as domestic, in a qualified sense; that is, so far as to give the right to so use the water, even though it may deprive lower proprietors of the opportunity of similar use, though this can not be done to the extent of cutting off the supply for drinking water, household purposes, or for stock.

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